
SCIENCE

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CONTENTS:

Color-Vision: PROFESSOR FRANK P. WHITMAN...305

A Half Century of Evolution, with Special Reference to the Effects of Geological Changes on Animal Life (III.): PROFESSOR ALPHEUS S. PACKARD..316

Reports of Committees of the American Association for the Advancement of Science:—
Sixteenth Annual Report of the Committee on Indexing Chemical Literature: DR. H. CARRINGTON BOLTON, CHAIRMAN....323
Report of the Committee on Standards of Measurement: PROFESSOR HENRY S. CARHART, SECRETARY....326

Current Notes on Anthropology:—
Initiation Ceremonies in Australia; The Tarascan Language; Anthropological Pessimism: PROFESSOR D. G. BRINTON....328

Notes on Inorganic Chemistry: J. L. H....328

Scientific Notes and News:—
Color-Vision: C. L. F. *Experiments with Kites at Blue Hill Observatory; The Prevention of Consumption; General*....329

University and Educational News....334

Discussion and Correspondence:—
Basil Valentine: PROFESSOR T. D. A. COCKERELL....335

Scientific Literature:—
Seward's Fossil Plants for Students of Botany and Geology: PROFESSOR LESTER F. WARD....335

Scientific Journals....340

New Books....340

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*COLOR-VISION.**

THE domain of physiological optics, formerly much frequented by students of physics, has of late been administered chiefly by psychologists. So far is this true that I have hesitated in preparing an address upon a subject in this realm, lest I should be accused of passing entirely beyond that borderland which lies between us and our sister science, of trespassing in a foreign country, and risking international complications. Yet a subject which has owed its development to Newton and Young, Maxwell and Helmholtz, to mention no other names, can hardly be out of place here. The methods of investigation are largely those of the physicist, the phenomena attend every optical research, the results are of frequent physical application. Within the past few years, however, most of the work on color-vision has been done by other hands, and the results have not appeared in the physical journals. It seemed worth while, therefore, to review briefly the progress of scientific theory in this direction, and to sum up, so far as possible, the present state of our knowledge.

For our purpose we must go back as far as Sir Isaac Newton, to whom we owe the first definite and intelligible hypothesis as to the nature of color-vision.

*Address of the Vice-President before Section B—Physics—of the American Association for the Advancement of Science, August, 1898.

"If at any time," he says, "I speak of Light and Rays as coloured or endued with Colours, I would be understood to speak not philosophically and properly, but grossly, and according to such Conceptions as vulgar People in seeing all these Experiments would be apt to frame. For the Rays to speak properly are not coloured. In them is nothing else than a certain Power and Disposition to stir up a Sensation of this or that Colour."

"For as Sound in a Bell or musical String or other sounding Body is nothing but a trembling motion, and in the Air nothing but that Motion propagated from the Object, and in the Sensorium 'tis a Sense of that Motion under the form of Sound; so Colours in the Object are nothing but a disposition to reflect this or that sort of Rays more copiously than the rest; in the Rays they are nothing but their dispositions to propagate this or that motion into the Sensorium, and in the Sensorium they are Sensations of those Motions under the forms of colours."*

Again, with greater definiteness, Newton writes: "To explain colours, I suppose that as bodies of various sizes, densities, or sensations, do by percussion or other action excite sounds of various tones, and consequently vibrations in the air of different bigness, so the rays of light, by impinging on the stiff refracting superficies, excite vibrations in the ether * * * of various bigness; the biggest, strongest, or most potent rays, the largest vibrations; and others shorter, according to their bigness, strength, or power; and therefore the ends of the capillamenta of the optic nerve, which pave or face the retina, being such refracting superficies, when the rays impinge upon them, they must there excite these vibrations, which vibrations (like those of sound in a trunk or trumpet) will run along the aqueous pores or crystalline pith of the capillamenta, through the optic nerve into the sensorium; and there, I suppose, affect the sense with various colours, according to their bigness and mixture; the biggest with the strongest colours, reds and yellows, the least with the weakest, blues and violets; the middle with green; and a confusion of all with white, much after the manner that in the sense of hearing, Nature makes use of the aërial vibrations of several bignesses, to generate sounds of divers tones; for the analogy of Nature is to be observed."*

*Opticks: 3d edition, 1721, p. 108.

These passages are quoted—and several others might be added—to show that Newton ascribes no peculiar function or activity to the terminals of the optic nerve. They are set in vibration by the rays of light; their vibrations are transmitted to the higher regions of the sensorium, where they become sensations of light and color. As to the physical nature of the rays themselves, or the reason why they should excite in the nerve-fibres vibrations of different length, Newton makes no guess.

This is a definite theory of color-perception, and, as Rutherford has pointed out, one of great value, but presenting obvious difficulties.

Some of these difficulties led Thomas Young to that modified form of Newton's views, which in the famous Bakerian lecture, he describes as follows: "Since * * *, it is probable that the motion of the retina is rather of a vibratory than an undulatory nature, the frequency of the vibrations must be dependent on the constitution of this substance. Now, as it is almost impossible to conceive each sensitive point of the retina to contain an infinite number of particles, each capable of vibrating in perfect unison with every possible undulation, it becomes necessary to suppose the number limited, for instance, to the three principal colours, red, yellow and blue * * * and that each of the particles is capable of being put

*Quoted by Young, *Phil. Trans.*, 1802, p. 19.

in motion less or more forcibly, by undulations differing less or more from a perfect unison; * * * and each sensitive filament of the nerve may consist of three portions, one for each principal colour." Young, as is well known, afterward substituted green for yellow, in his triad of principal colors.

It is to be observed that the 'particles' spoken of in the above quotation, as vibrating in unison with the undulations of light, are not to be considered as molecules, in the modern sense. He speaks of them as particles, then as sensitive filaments, and in a later paper on the same subject as 'sympathetic fibres.' A supposition, such as has been urged, that Young is here speaking of molecular constitution, and anticipating the photo-chemical theories of our own day, is an anachronism. Young is thinking of the wave-theory of light, and of sympathetic vibrations, or, as we should say, of resonance. One who meant chemical decomposition would not speak of the shattered molecules as *sympathetic fibres*. Young, in fact, is not consciously proposing a new theory, much less one so startlingly different. He is simplifying Newton's, making for that purpose four hypotheses, three of which, as he remarks himself, 'are literally parts of the more complicated Newtonian system.' Young's theory seems to have attracted little attention, until brought once more to public notice by Helmholtz, in 1860.

Helmholtz suggests one objection to the theory, and a modification to obviate the objection, but remarks that the essence of the theory does not lie in this or that special assumption, but in the fact that the color-sensations are conceived as compounded out of three entirely independent properties in the nerve-substance.

Therefore, he says, if only for the sake of clearness of representation, he uses Young's original and simple form of statement, ascribing the different color-sensations to three-kinds of nerve endings in the retina, sensitive respectively to red, green and violet light, the sensation of white to the equal excitation of all three sets of nerve-fibres, and color-blindness to the absence of one or more of the sets of such fibres. He puts into Young's words, however, an entirely different meaning, by classifying Young's hypothesis as 'only a special application of the law of specific sense-activities.' This statement, a most natural one to a pupil of Johann Müller, changes the whole character of the theory, and makes it really a new one.

The hypothesis in this simple form met very well the conditions of normal vision, and the cases of color-blindness thus far studied. Difficulties soon arose. Color-blindness, especially red-blind persons, persisted in calling the principal colors seen in the spectrum, yellow and blue, instead of green and blue, as they should have done if the red sensation were simply absent. It was long supposed that this was merely a question of naming the colors, and that those actually seen were green and blue. So lately as 1892 the report of the British Association committee on color-vision contains colored spectrum-plates, in which the spectrum as seen by a red-blind person is shown as composed of green and blue, while that seen by a green-blind person is formed of red and blue. Abney prefixes the same plate to his Tyndall lectures on color-vision, published in 1894. But in 1881 Hippel* and Holmgren† had examined the vision of a person, one of whose eyes was normal, the other typically color-blind. All the long-waved end of the spectrum was described as yellow, the sensation being tested by comparison with the normal eye. Other cases of color-blindness, arising from disease, corroborate this testimony.

* Arch. f. Ophthal., XXVI. (2), p. 176, 1880; XXVII. (3), p. 47, 1881.

† See Proc. Roy. Soc., No. 209.

It is evident that a simple absence of one of the fundamental sensations is not enough to account for the facts.

But more than the ordinary color-blindness comes into the question. It was discovered that the normal eye is color-blind by indirect vision, the condition gradually increasing from the central portion outward, and culminating in the periphery of the retina in absolute insensibility to color. The sensation of white cannot in this case be produced by a mixture of three color-sensations, because color-sensation does not exist.

In 1777 was described, in the Philosophical Transactions of the Royal Society, the well-known case of the shoemaker Harris, apparently the first recorded case of complete color-blindness. In 1871 Donders made a careful study of another case. So rare is this defect, however, that so assiduous an observer as Holmgren in 1877 had never seen it and doubted its existence, and in 1889 Helmholtz simply passes it by, saying that the eye so affected is always in other ways ailing and sickly, the implication being that the effect was so far from the ordinary and so pathological in character that it need not be considered. But by 1892 a sufficient number of such cases had been examined to establish the existenee of this as a distinct type of color-vision, and one which must be accounted for.

A third and even more striking departure from the simple conditions of the original theory was found in the remarkable change in the character of color-sensations in faint light, the spectrum becoming simply a colorless strip of graduated brightness.

We have then three different types of varying color sensibility :

1. In the eyes of different persons, beginning with the normal-eyed, passing through the variation studied by Rayleigh and Donders, which while recognizing all colors, yet in the character of the sensations makes a step toward green-blindness, then the two well-marked divisions of the color-blind, red- and green-blind, and finally the eye which perceives no color. These different classes are well marked, and few intermediate forms are found.

2. In the same eye, under differing degrees of brightness. As the spectrum gradually diminishes in brightness the colors change. Red tends toward yellow, yellow toward green, green becomes bluish. All the colors vanish by degrees, red disappearing first, and the spectrum, still visible through the greater part of its length, appears without color. Here the intermediate stage is a sort of red-blindness, but the final result is the same for all eyes, that is, the distribution of brightness for the normal and the color-blind eye appears to be precisely the same, a circumstance, as we shall see, of much importance.

3. In a single eye, passing from the center outward. The fovea and the zone surrounding it are sensitive to all colors. Outside of this the eye becomes gradually insensitive to color, the sensation of red and green disappearing first, afterwards yellow, and finally blue. The outer part of the retina is insensitive to all color, but its condition may be quite different from that of the eye of a totally color-blind person, or a normal eye in faint light.*

In attempting to account for these varied phenomena the Helmholtz theory loses its striking simplicity. It is no longer possible to explain color-blindness by the absence of one or more sets of sensitive fibres, or the white seen by a totally color-blind retina, as compounded from the three fundamental sensations, in any ordinary way.

Helmholtz, in 1860, made the suggestion, which was afterward amplified by Fick and König, of a possible changeability in the

* von Kries, *Centralblatt f. Physiologie*, X., pp. 745-749, 1896.

character of the three fundamental sensations. Albert, in 1882, from a study of the color changes in faint light, pointed out the direction and character of the corresponding sensation-changes.*

A method by which such changes might be brought about was not difficult to suggest. The idea of Newton and Young, of nerve-fibres vibrating in unison with the light-waves, had grown increasingly improbable as, on the one hand, the rate of vibration of light became known, and on the other the maximum rapidity of vibration transmissible by a nerve-fibre, which is a quantity of an entirely different order. Hence most modern theorists have turned to photo-chemical action, and Helmholtz among the rest, although with characteristic caution, he advocates no particular form of light effect, resting the claims of his theory, in the second edition of his great book as in the first, on the physical possibilities of representing all colors by means of three. But if we suppose red-sensitive, green-sensitive and violet-sensitive molecules, there is no difficulty, when one thinks of modern photographic processes, in supposing that the green-sensitive substance, for example, may be so chemically changed as to coincide in character with the red-sensitive. Each would send to the brain the impression of its own characteristic color, while each would be affected in exactly the same manner by any given light. In other words, the color curve corresponding to the sensation of the fundamental green in the Young-Helmholtz theory would be more or less perfectly superposed upon that of the fundamental red. As a result, there would be no more sensation of green or red, but only of their compound, yellow. Now this is just what a color-blind person sees, as Hippel and Holmgren showed in their long-neglected papers already referred to.

*Albert, *Wied. Ann.*, 16, p. 129, 1882.

So peripheral color-blindness may be explained by a gradual approximation of the three color-substances, and a gradual superposition of the corresponding sensation-curves, until in the outer zone all three coincide.

But when we attempt to apply this suggestion to all the changes noted before, in ordinary color-blindness, peripheral color-blindness and twilight color-blindness, as von Kries happily calls it, the shifting of the curves becomes so great and so various that we realize that we are dealing no longer with a scientific theory, but with fanciful and arbitrary arrangement. As a first approximation, the Young-Helmholtz hypothesis is valuable, leading to simple and definite connections between great numbers of facts. As a detailed explanation of existing phenomena it is unsatisfactory, and growing more so daily.

One thing is becoming steadily evident, that the sensation of brightness, perhaps also the sensation of white, must be accounted for in some other way than as a summation-effect of separate color-sensations. Another class of phenomena points yet more directly to this view. I refer to the discovery of Rood that the effect of sudden variations in brightness, the 'flicker' sensation, is dependent on brightness alone, and not upon color. It is difficult for one who has seen how easily and definitely a red and a gray, or a red and a blue, can be compared in brightness by this method, to believe that brightness is not an independent sensation. The words of Helmholtz are worth quoting here. "As to myself," he says, "I have always the feeling that in photometric comparison of different colors it is a question, not of the comparison of one sort of magnitude, but of the combined effects of two, brightness and color, of which I cannot form a simple summation and of which I can give no scientific definition."

The strongest point of attack upon the

Young-Helmholtz color-theory has, in fact, always been the explanation of the white-sensation, and one of the principal advantages of the theory proposed by Hering in 1874 was the separation of the white-sensation, which he identified with the sensation of brightness, from special connection with the color-sensations, or rather his including it, upon the same level, in the list of his three sets of opposing colors, black-white, red-green, yellow-blue.

A photo-chemical substance is supposed to exist in the eye—where it is not decided—which possesses the remarkable property that if acted upon by light of one wave-length its molecules are dissociated or dissimilated ; if acted upon by light of another wave-length they are built up or assimilated again. This substance exists in three forms : One is, let us say, dissimilated by red light, assimilated by green ; one is similarly acted upon by yellow and blue, and one by white and black. There are thus six color-processes, arranged in three pairs. They are antagonistic in character, so that if red and green, or yellow and blue light act on the retina at the same time and with equal strength they neutralize each other and the sensation of color is completely destroyed. It is difficult to form a clear conception of these processes. Photo-chemical actions of somewhat antagonistic character are well known, but the analogies between them and the visual processes are hardly close enough to be of great assistance.

The hypothesis, however difficult to conceive of in itself, is very definite, and explains as well as the Young-Helmholtz theory the results of ordinary color-vision, and in respect to subjective phenomena, as contrast, or after-images, is much more satisfactory, in formal statements at least. But it fails equally, though for different reasons, to explain satisfactorily the more lately discovered or less evident phenomena of vision.

Complementary colors are regarded, on this theory, as mutually destructive, the one representing an assimilative, the other a dissimilative process. The white or gray which results from their combination is due to the action on the white-black visual substance, which was unperceived in the separate colors, being masked by their greater brilliancy, but becomes effective when they are neutralized by mixture. If two equal grays are formed, one let us say from red and green, the other from yellow and blue, they must according to the theory contain equal amounts of white, and the colors in each are completely neutralized. They should, therefore, remain equal at all degrees of brightness. But Ebbinghaus,* by mixing spectral colors, and Mrs. Franklin,† with color-disks, have shown that this is not true. If they are made equal when bright, and the intensity gradually diminished, the red-green mixture greatly exceeds in brightness. If they are equated when of feeble intensity, and then made brighter, the yellow-blue mixture surpasses. König‡ has lately examined this with much elaboration, confirming these results, and showing also that the brightness of a gray obtained thus by mixture is always equal to the sum of the brightness of the separate colors, whether by bright or faint light.

This single experiment, so amply confirmed, appears completely destructive to Hering's fundamental hypothesis, at least in its original and simple form.

It may be remarked in passing that photometric methods which have been proposed, of comparing lights of different colors by reducing their brightness until the color-differences vanish, are worthless.

Other phenomena of similar character exist which are equally difficult of explana-

* Zeitschrift für Psychol. und Physiol. Sinnesorgane, V., p. 145, 1893.

† Mind, N. S., II., p. 487, 1893.

‡ Ber. d. Preuss. Akad., p. 945, 1896.

tion. Hering regards some of these as phenomena of adaptation, and shows, in his remarkable paper on Purkinje's phenomenon, published in 1895, that the state of the retina, as conditioned by previous exposure to light, affects greatly the perception of color. Attention to this fact is necessary in photometric comparisons. The eye should be kept in the same condition, as nearly as possible, throughout any set of observations. But careful measurements by von Kries and others, keeping the eye carefully adapted for brightness, have proved that Purkinje's phenomenon exists, whatever the state of the eye, though much modified by adaptation.

Another cause of false color-appreciation, insisted upon by Hering, is the pigmentation of the macula. This is certainly of importance. In experiments with color-disks the apparatus, to secure consistent results, must always be placed at the same distance from the eye. A color-match made with the disks close to the eyes will in general not hold if the observer steps back a few feet, because the macula covers in the two cases a very different portion of the retinal image of the disks. The region corresponding to the macula, indeed, can generally be seen projected upon the surface of the revolving disks, as a spot inclining more to reddish than the remainder of the surface. The intensity of the yellow pigment, differing in the eyes of different people, must affect their general perception of color.

The well-marked divisions of color-blind, into green-blind and red-blind, as they would be called in the Young-Helmholtz theory, were explained by Hering as due to the more or less deeply pigmented macula. But the utter inadequacy of this explanation has been abundantly shown.

Perhaps the most striking difference between the Hering hypothesis and the facts is shown in the distribution of color-sense in different parts of the retina. Ability to distinguish colors decreases gradually from the center to the exterior. The distinction of red and green disappears first, then the yellow becomes uncertain, and finally blue disappears, the outer zone of the retina being devoid of color-sense. The zones are not well defined, varying with the brightness of the light and the size of the colored surface. But making due allowance for these circumstances, the area within which red is distinguishable differs from that occupied by green, and the yellow sensation differs in extent from the blue. If red and green, or yellow and blue, are due to the presence of the same visual substance it seems that the boundaries should be co-extensive.

Even the sensation of white presents similar variations. There are, as has been already said, three cases in which the color-sense is wanting: the totally color-blind eye, the normal eye in faint light, and the periphery of the retina. The brilliant discovery of Hering, in 1891, that the distribution of brightness in the spectrum in the first two cases is the same, aroused great interest in the theory of the sensation of white, and went far toward establishing its position as a distinct and separate sensation. The third case, it was taken for granted, fell under the same law. But in 1896 von Kries showed that the distribution of brightness in the spectrum as seen by the outer zone of the retina is different, being practically the same as in the central portion, with its maximum in the yellow, and that the peripheral zone in the retina of a color-blind person shows the same deficient sensation for the longer wave-lengths as in the color-perceiving portion of the eye.

This is a matter of so much interest that I have re-examined it with the flicker photometer, with results differing materially from those of von Kries. According to my experiments, the brightness of the colors of

long wave-length diminishes continually, while that of the shorter wave-lengths increases continually, from the center of the visual field to its circumference. The conditions under which von Kries worked, however, were so different from mine that I cannot regard my results so far as necessarily invalidating his. If his results are confirmed, they show that the sensation of white in the normal eye is not completely determined by the twilight sensation, or that of the totally color-blind. It contains elements derived from, or connected with, the mechanism producing the sensation of color, even in those portions of the retina where no color-sensation exists.

I have discussed these two theories somewhat at length, because our growth in knowledge of the facts of color-sensation has been conditioned largely by their existence. The enormous amount of work which has been done on the vision of the color-blind, on color-vision by varying illumination, on peripheral color-vision, not to mention researches upon more purely subjective phenomena, has been largely suggested by aspects of one or the other of these theories, or undertaken with a view to testing portions of them, and there has seemed no better method exhibiting the results of these researches than by placing them in connection with the hypotheses they were intended to test. I need hardly add that I have been greatly aided in this summing up by the polemical writings emanating from the hostile schools.

In this respect, at least, the two theories have been eminently useful, and have fulfilled one of the chief requirements of a scientific theory—that its explanations can be tested by experiment. The earlier forms of color-theory suggested by Newton and by Young were hardly such. So long as the specific effect was conceived to be entirely in the central organ, to which the nerves merely communicated the vibrations of light, there was little upon which to base experimental work. Helmholtz, by ascribing the specific activity to the nerve-ending itself, made it necessary to describe this activity in some definite way, which could then be tested. The very simplicity of the conceptions of Helmholtz and Hering, at first the apparent guaranty of their truth, has proved their greatest value, but also their greatest difficulty.

It is not to be wondered at that later theorists have attempted to modify one or the other of these hypotheses instead of starting anew. Many such attempts have been made in the last few years, but few have attained more than a passing notice, and none any general acceptance. One or two, however, are of considerable intrinsic interest, and may command attention for a brief period.

Ebbinghaus attempts to advance a step upon the older theories by assigning to a particular retinal substance the function of color-stimulus. He finds this substance in the so-called visual purple, which was studied with great care by Kühne more than twenty years ago. This remarkable substance is reddish purple in its normal condition. On exposure to light it bleaches rapidly, passing through a series of tints until it becomes yellow. On further exposure to light it becomes colorless, but in the dark regains its original purplish tone directly without passing again through the series of changes in color. The color-stimulus is ascribed by Ebbinghaus to the absorption of light by the visual purple, and the character of the light-sensation is directly dependent on the color of the light absorbed, that is, upon the physical properties of the substance.

The purple substance, which is changed by the action of light into the 'visual yellow,' is identified by Ebbinghaus, in its two stages, with the 'yellow-blue' substance of Hering. In its first stage it gives

rise to the sensation of yellow, in the second stage to that of blue. The visual purple pertains to that element of the retinal complex known as rods. These are not present in the central portion of the retina, and the visual purple is apparently absent there also. But the fovea is sensitive to blue and yellow, as also to green and red Ebbinghaus supposes that a red-green substance exists, even in the fovea, green in its first stage, red in its second; that the yellow-blue substance exists also in the fovea, but that the two, present there in about equal quantity, and nearly complementary in color, neutralize each other, leaving the fovea colorless. A white-sensitive substance is also supposed to exist, more sensitive to light than any of the colored substances, and thus we arrive at three sets of color-processes, similar to those of Hering. The two types of color-blindness are explained by reference to the fact that there are two kinds of visual purple, found in the eyes of different animals, one more relatively red in tone, the other inclining more to violet. The red-blind are supposed to possess one of these, the green-blind the other. Certain anomalous and pathological color-sensations are supposed to be due to disturbances in the conducting nerves or the central organs, and hence need not be fitted into the scheme thus outlined.

The physiological character of this theory, as Mrs. Franklin has shown, can probably not be sustained. It is difficult to believe that such a balance between the visual purple-yellow and the supposed visual red-green could exist, in all stages of both, that they would remain always complementary, and so the latter always invisible. Yellow light, according to this theory, should be most active upon the visual purple, but, as a matter of fact, this material is bleached very slowly by sodium light, and, indeed, König has shown that its maximum absorption is not in the yellow, but in the green. The visual purple exhibits other striking properties, of which the theory takes no account. It seems probable, on the whole, that the office of this substance is really a very different one, and that if it is concerned at all with vision it is with the sensation of white light, not colored.

The theory of Ebbinghaus, then, if we deny its connection with the visual purple, rests upon the same basis as that of Hering, —a visual substance not identified, perhaps not discoverable, but recognizable only through the precision with which it explains phenomena, and the hypothesis itself becomes in the main a modification of Hering's with the well-known pairs of photo-chemical substances, modified in their character so as to meet the facts more perfectly, removing some difficulties, but introducing others.

The chief advantage of the hypothesis for explanatory or speculative purposes lies in its greater freedom. The theory of Hering demands six color-processes. These are so connected together that they make not six, but three, independent variables. Ebbinghaus so constructs his substances as to leave them nearly independent, the blue, for instance, no longer serving as the antagonistic substance to the yellow, but regarded as developed out of it, and possessing specific properties of its own. Under certain conditions the color-substances are supposed to neutralize each other, as with Hering, a supposition which adds greatly to the difficulty of the hypothesis ; but, in general, five independent variables are at the command of the theorist, which, it is evident, may be endowed with such various properties as to explain almost any conceivable difficulty of color-vision.

It may also be said that, with such an assortment of visual substances at command, the properties of which have at present no known chemical, physical or physiological relations, but are deduced entirely from the

sensations dependent upon them, the phenomena might probably be explained in an indefinite number of ways, and the different methods of explanation should be regarded rather as examples of ingenious speculation than as real contributions to the advancement of science.

To such a category belong many of the later theories of vision. They incline to Helmholtz or to Hering according as their point of view is chiefly physical or psychological, for the standpoint of these two theories is fundamentally different.

Helmholtz, showing that all colors can be compounded from three, and that white may be also compounded, assumes that three color-sensations are sufficient, and that white may be regarded as a compound sensation. Hering, relying more upon the direct deliverances of consciousness, denies the compound nature of the sensations of white and of yellow, whatever their physical composition may be, and says explicitly that "the entire separation of the optical nature of a light from the sensation which it arouses in us is one of the most necessary prerequisites to a clear handling of the theory of color." Along the lines of these two theories, then, new hypotheses move, and will move, since each of them stands for something real, and has its own distinct advantages.

Upon a somewhat different basis rests a theory, hardly so much of color as of light-sensation, which was hinted at by various observers, but most clearly worked out by von Kries. This supposes that we possess two entirely distinct kinds of visual apparatus, one dependent upon the cones of the retina, the other upon the rods, and the visual purple connected with them.

Max Schultze, so long ago as 1866, mainly on anatomical grounds, suggested that the rods were probably the most important organs of vision in faint light. Animals which prey by night, as cats, moles, owls, etc., possess retinas rich in rods, but with cones either few or absent. Our own eyes perceive faint light more readily with the peripheral portions of the retina, where rods are numerous, than with the central portions, where they are few.

Helmholtz* pointed out the fact that if the visual purple is actually connected with vision it must have to do with peripheral rather than central vision, since it is absent from the fovea, and suggested that it might have to do with the perception of faint light.

In 1894 König studied the absorption curve of the visual purple, finding it substantially identical with the curve of brightness for the spectrum of low luminosity. von Kries, combining these and other suggestions, considers the visual purple in the rods to be, in the human eye at least, the active agent for the perception of faint light. He shows that the phenomena of adaptation point in the same direction. In strong light the visual purple is soon bleached. An eye 'adapted for brightness' is very deficient in power to perceive faint light. If it is now kept in darkness for about half an hour this faculty is enormously increased. But in about the same period the visual purple is practically restored. The essence of adaptation is the recovery of the visual purple. Red light, which does not act upon this substance, does not destroy the sensitiveness to faint light in an eye which has been exposed to it for even a considerable time.

If vision by faint light depends, wholly or partly, on the decomposition of the visual purple, and if light of long wave-lengths does not effect this decomposition, blue light when faint should appear much brighter than red, and Purkinje's phenomenon is thus easily explained. But in the fovea, where the rods and the purple are not present, this sensation of colorless faint light

* Physiol. Optik, 2d. ed., p. 268.

should not exist, and the color of any light bright enough to affect this portion of the retina at all will at once be recognized. von Kries declares this to be a fact. Two colors, equally bright in strong light, will remain so at all illuminations if their image falls entirely on the fovea ; but, if not, the color which is of the shorter wave-length will in general be the brighter.

Vision by strong light, and color-vision, since both are possessed by the fovea, must be effected by the mechanisms of that retinal area, and these sensations von Kries attributes to the cones, which are supposed to be furnished with a tri-chromatic color-apparatus, and to afford the sensations of color and a compound sensation of white. If objection is made to the compound white the details of this latter apparatus might be varied, might even approximate that of Hering's theory, without affecting the importance of the hypothesis, the essence of which is the twofold nature of the sensation of brightness.

Such a theory explains easily the fact that grays compounded from different pairs of complementary colors, and equally bright in ordinary light, cease to be so in faint light. They are equalized at first by the cone-apparatus, and are seen in the faint light chiefly by the rod-apparatus, in which the scale of brightness is entirely different.

G. E. Müller makes the acute suggestion that the visual purple may not be a visual substance at all, properly speaking; but, while concerned chiefly with the phenomena of adaptation, may act also as a *sensibilisator* —to borrow a photographic term—for the white-sensitive substance, increasing its susceptibility in faint light. This modification of von Kries' hypothesis is perhaps simpler than the original and equally satisfactory.

Still another hypothesis for separating the white from the color-sensations is that the sensation of white, from an evolutionary standpoint, was developed earlier than the sensations of color, and that the mechanisms of the latter are to be regarded as evolved from that of the fundamental sensation, and as modifications of it. Upon this idea Mrs. Franklin has founded her ingenious theory of light-sensation. Abney has made a similar suggestion, but in general terms only.

Such is a brief and hasty summary of the progress of color-theory. We may well ask for the result. In the general shifting, what views have maintained or gained a footing? A few, I think, are fairly well established.

1. The number of color-sensations is small, and all color-theories positing a large number are to be distrusted. If experimental work is of any value whatever, it is certain that all light-sensations, for all purposes, may be expressed by a small number of variables. The Young-Helmholtz theory demands three. Hering's requirements, as Helmholtz has shown, may be expressed in terms of three, although the number of fundamental color-sensations, using color in its ordinary sense, is four. Such theories as those of von Kries and Mrs. Franklin require four variables, such as that of Ebbinghaus five. The introduction of a much larger number is gratuitous and unnecessary.

2. Out of this number of variables at least one is to be alloted to the white-sensation, or that which is closely akin to it, the sensation of brightness. It is no longer possible to think of white entirely as a compound sensation, however it may be compounded physically. It is unnecessary to recapitulate the arguments for this statement, drawn largely from the three forms of total color-blindness.

3. White, however, can hardly be thought of as an entirely independent sensation. The phenomena of vision by faint light, the facts of peripheral vision, show that, under certain circumstances, color-sensations contribute their quota to the colorless one, and in differing amounts at differing brightness.

These phenomena are not satisfactorily handled by any of the principal theories. They are fairly well explained by the Helmholtz suggestion of shifting color-curves, nearly as well by the hypothesis of Hering and Hillebrand, that color-sensations possess specific brightening or darkening power, which makes itself more notable as the intensity increases. These are but formal explanations, however, and increase rather than diminish the difficulties of the theories to which they are attached.

4. The theory of von Kries, of different visual mechanisms for bright and faint light, supplements excellently the existing theories, and must be regarded as a distinct step in advance.

5. A definite and highly probable function has been assigned to the visual purple, the function of adaptation, and of causing or aiding vision in faint light.

Farther than these at present we can hardly go. The number and variety of known phenomena are great and constantly increasing. Their inter-relations grow every day more complex, and the actual mechanism governing those relations still remains almost entirely unknown. Subjective experiment appears likely to yield little more aid. The various theories have arrived at such a state of perfection, and, thanks to subsidiary hypothesis, to such a state of flexibility, that almost any visual result might probably be explainable by either. Perhaps the most hopeful line of research is that which, like König's study of the visual purple, seeks to find some relation between color-sensations and physical properties. Since so many phenomena point to photo-chemical changes in the eye, it would not be surprising if the next advance should come from the chemical side, rather than from the physiological, physical or psychological, which have held the field so long.

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*A HALF-CENTURY OF EVOLUTION, WITH SPECIAL REFERENCE TO THE EFFECTS OF GEOLOGICAL CHANGES ON ANIMAL LIFE (III.).**

4. THE UPPER CRETACEOUS REVOLUTION.

ANOTHER profound and epoch-making change occurred at the beginning of the Upper Cretaceous. In Eurasia, as Kayser states, "this was one of the greatest changes in the distribution of land and water over almost the whole earth that is known in geographical history. Extensive areas which had for long periods been continents were now overflowed by the sea and covered with Cretaceous deposits;" the Upper Cretaceous strata in certain areas in Germany and Belgium resting directly on archean rocks. In America (the Dakota stage) there was also a great subsidence. The Atlantic coastal plain was submerged over what was Triassic soil, also the lowlands from New Jersey through Maryland to Florida, while the Gulf of Mexico extended northward and covered western Tennessee, Kentucky and southern Illinois; a wide sea connected the Gulf of Mexico with the Arctic Ocean, and thus the North America of that time was divided into a Pacific and an Atlantic land, the latter comprising the Precambrian and Paleozoic areas.

As Scott states: "The Appalachian mountains, which had been subjected to the long-continued denudation of Triassic, Jurassic and Lower Cretaceous times, were now reduced nearly to base-level, the Kittatinny plain of geographers. The peneplain was low and flat, covering the whole Appalachian region, and the only high hills upon it were the mountains of western North Carolina, then much lower than now. Across this low plain the Delaware, Susquehanna and Potomac must have held very

* Address of the Vice-President before Section F—Zoology—of the American Association for the Advancement of Science, August, 1898; concluded from SCIENCE, September 2d.

much their present courses, meandering through alluvial flats" (p. 481). An elevatory movement began in the succeeding or Colorado epoch, and this was succeeded by an uplift on the Atlantic and Gulf coasts, and the continued upheaval in the interior resulted in the deposition of the Laramie brackish and fresh-water beds. There were similar widespread subsidences and upheavals in South America, the Andean chain being in large part upheaved at the close of the Cretaceous.

In the Cretaceous period there were such differences in the distribution of the fossils as to lead Römer, from his explorations in Texas as early as 1852, to consider that the resemblance of the fossils of Texas, Alabama and Mexico, with the West Indies and Colombia, to those of southern Europe were due to differences of climate, a view reiterated by Kayser (p. 283). Scott also states that the Lower Cretaceous beds of Texas show faunal resemblances which ally them to the Portugal and Mediterranean beds, while the faunal relations of South American Lower Cretaceous strata are closely like those of northern and western Africa.

The biological changes at the beginning of the Upper Cretaceous were correspondingly notable. Vast forests of conifers, palms, and especially of deciduous trees, such as the oak, sassafras, poplar, willow, maple, elm, beech, chestnut and many others, clothed the uplands, while in the jungles, on the plains and in the openings of the forests gay flowers bloomed. The flora must even then have been, comparatively speaking, one of long existence, because highly differentiated composite plants, like the sun-flower, occur in the Upper Cretaceous, or Raritan clays, of the New Jersey coast. It may be imagined that, with this great advance in the vegetation, the higher flower-visiting insects must have correspondingly multiplied in number and variety.

While the changes of level did not affect the abysses of the sea, the topography of the shallows and coast was materially modified, and to this was perhaps largely due the extinction of the ammonites and their allies.* It is not impossible that the uncoiling of the ammonites into forms like Scaphites, Crioceras, Helioceras, Turrilites and Baculites were originally perhaps distortions due to physical causes somewhat similar to those which produced a loosening or uncoiling of the spire in Planorbis. These variations or distortions of the pond snail, signs of weakness, the result either of pathological conditions or of senility, were due to unfavorable changes in the environment, such as either a freshening of the

*After preparing this address I find that Wood thirty-six years ago more fully discussed this matter and mentioned the same cause I have suggested. "This disappearance," he says, "of the Ammonitidæ and preservation of the Nautilidæ we may infer was due to the entire change which took place in the condition of the shores at the close of the Cretaceous period ; and this change was so complete that such of the shore followers as were unable to adapt themselves to it succumbed, while the others that adapted themselves to the change altered their specific characters altogether. The Nautilidæ having come into existence long prior to the introduction of the Ammonitidæ, and having also survived the destruction of the latter family, must have possessed in a remarkable degree a power of adapting themselves to altered conditions." On the other hand, the dibranchiate cephalopods (cuttles or squids), living in deeper water, being 'ocean rangers,' were quite independent of such geographical changes. Wood then goes on to say that the disappearance of the tetrabranchiate group affords a clew to that of the Mesozoic saurians, and also of cestraciont sharks, whose food probably consisted mainly of the tetrabranchiate cephalopods. "Now the disappearance of the Tetrabranchiata, of the cestracionts and of the marine saurians was contemporaneous ; and we can hardly refuse to admit that such a triple destruction must have arisen either from some common cause or from these forms being successively dependent for existence upon each other." He also suggests that the development of the cuttles 'has been commensurate with that of the cetacean order, of some of which they form the food.' (*Phil. Mag.*, XXIII., 1862, p. 384.)

water or some other chemical alteration in the relative amount of alkalines and salts. The changes in the ammonites, though more remarkable, are similar to the aberrations observable in the shells of the upper and later layers of the Steinheim deposits, made known to us by Hilgendorf, Sandberger, and more especially by the detailed and masterly researches of Professor Hyatt.

In this case the Miocene Tertiary *Planorbis lævis* was supposed to have been carried into a new lake, before untenanted by these shells. Although from some unknown cause the lake was unfavorable to the production of normal *lævis*, whose descendants show the results of accidents and disease, yet, owing to isolation, which prevented intercrossing with the present stock, and to the freedom from competition, the species was very prolific, and the lake became stocked with a multitude of more or less aberrant forms constituting new species. Some of them are nearly normal, with a flat spire; others are trochiform, and others entirely unwound or corkscrew-shaped. Similar aberrations occur in *Planorbis complanatus*, living in certain ponds in Belgium (Magnon); in the slightly twisted Planorbid, *Helisoma plexata* Ingersoll of St. Mary's Lake, Antelope Park, Colorado, and in the unwound forms of Valvata first found by Hartt in Lawlor's Lake, near St. John, New Brunswick, and described by Hyatt.* In all these cases of parallelism or convergence the aberrations seem to have been due to some unusual condition of the water adverse to normal growth. Hence it is not impossible that the singular uncoiled or straight forms assumed by certain of the ammonites when on the verge of extinction were likewise cases of convergence and due to weakness or senility, or at least to an unusual and unfavorable condition of the seas in which they lived.

*Annual Report of Hayden's U. S. Geol. and Geogr. Survey of the Territories.

The physical causes of extinction of the Mesozoic reptiles may also have been due to or connected with the changes of coast level, although signs of weakness and senility are exhibited by these. In the Como or Atlantosaurus beds referred by Scott to the Lower Cretaceous rather than Jurassic, the ichthyosaur (*Sauranodon natans*) was toothless, while the colossal Cretaceous pterodactyle, Ornithostoma (Pteranodon), was entirely toothless.

The colossal Pythonomorpha, offshoots of terrestrial lizards, but with paddles adapting them for marine existence, succeeded the plesiosaurs, and may have materially aided in their extinction. Hence arises the question: Did the extinction of the marine reptiles result in or contribute to the great increase of teleost fishes?

Before the dinosaurs began to die out the type in part became specialized into lizard-like tree-climbing forms and agile bird-like forms. The first birds of the Cretaceous were toothed, carinate, highly predaceous forms, with a retrogressive side-branch of wingless diving birds, represented by the colossal Hesperornis, but in this case the loss of teeth was undoubtedly a gain to the type, compensation for the lack of a dental armature in the seed-eating birds being shown in the elaboration of a gizzard.

5. GEOLOGICAL CHANGES IN THE TERTIARY.

Here again we have, as in former periods, a succession of earth-movements, subsidences in one region and elevations in another, though apparently more limited in extent than before, the oscillatory movements being rather confined to coastal areas, and involving adjacent shallow seas, there being frequent alternations of marine with brackish and fresh-water beds. As Kayser remarks, the Tertiary deposits "no longer extended unaltered over whole countries like those of older systems, but generally occupied only smaller basins or bay-

like areas, filled up inland seas or shallow gulfs" (p. 328). Towards the close of the Tertiary the great mountain ranges of Asia and Europe, the Alps, Pyrenees, Caucasus, Himalayas, as well as the Atlas, and the Cordillera of North and South America, were upheaved. The old Tertiary nummulitic beds were, in the western Alps, raised to a height of 11,000 feet, and the Himalayas to a horizon 16,000 feet above the sea, while there were corresponding elevations in western North America and in the Rocky Mountain region.

The evidence from fossils show, what has not been disputed, that the climatic zones were by this time established. In Europe the older Tertiary was decidedly tropical, in the Miocene subtropical, but the climate of Europe was somewhat lowered late in the Miocene, as shown by the absence of palms.* At the end of the Tertiary, *i. e.*, during the Pliocene the earth's climate was but slightly warmer than at present. It should here be noticed that while Greenland, Iceland, Spitzbergen and Grinnell Land under 81° north latitude were during the late Tertiary 'abnormally warm' the Tertiary floras of northeastern Asia, including those of Kamtschatka, Amurland and Saghalien and that of Japan, 'show no sign of a similar warmth, but rather point to a climate colder than that of the present day' (Kayser, p. 354).*

The Tertiary was apparently also a time of more or less inter-continental migrations or interchange of life-forms, which crossed the oceans over so-called continental bridges. Bering Strait was at one time such a bridge, and to explain the geographical distribution of certain forms there is thought to have been a more or less continuous land-connection between India and Africa, and between Africa and South America, and possibly in the Eocene between Australia and southwestern Asia.

However hypothetical these continental bridges may be, we do know that Central America and the Isthmus of Panama were elevated at the end of the Miocene, and that the bridge thus formed between North and South America became an avenue for the interchange of mammals and other animals which materially modified the distribution of life in the southern and northern parts of our continent.

*Jaeger suggests that the occurrence, in the later geological periods, of warm-blooded vertebrates, protected by feathers or hair, was due to the fact that the earth then became cooler than in the preceding ages. His explanation of the origin of feathers and hair is as follows: "If the average temperature of an animal body is considerably higher than that of the surrounding media, oscillations of these media have a stimulating effect upon the skin of the animal. This leads to a tendency to form papillary chorian (*sic*) cells, and these afterwards produce hair or feathers, which represent two of the most characteristic features of warm-blooded animals. He adds that this "stimulatory effect upon the skin can only be due to low temperatures." The body temperature of the birds and mammals being high, and the covering of the hair or feathers rendering them proof against the extremes of heat or cold, we can see that there is a coincidence between this and the fact that these classes began to increase in numbers towards the end of the Mesozoic, and especially at the opening of the Tertiary, when the climatic zones began to be established. So also in the case of whales the loss of hair is compensated for by the blubber. Why, however, feathers developed in birds, rather than hair, is a problem no one has attempted to solve, though feathers, of course, better adapt the bird to flight; no flightless birds having such well developed feathers as those capable of extended flight. (See G. Jaeger, Problems of Nature, Translated by Henry G. Schlichter, D.S.C., London, 1897, p. 66.)

It might be suggested that the broad vane-like surface which characterizes feathers as compared with hairs may have been due to the fact that they would better support the body in flight; this difference from scales, as well as their greater lightness, giving this sort of armature an advantage over scales on the one hand and hairs on the other.

*It has also been claimed by J. W. Gregory that the fossil plants of the Greenland Miocene beds may have been drifted from the southward, and that the temperature of the Polar region was not so elevated as Heer had been led to suppose. (*Nature*, Vol. 56, p. 352, 1897.)

The elevation of the West Indies took place at this date, and these islands were peopled from the South American coast. What we already know of the rapid evolution of molluscs, insects and mammals on these islands shows how closely dependent variation and adaptation are on isolation as well as changed topographic and climatic features.

These problems have been studied with great care in the Hawaiian Islands by Gulick, and more recently by Hyatt. As well stated by Woodworth: "With the development of the umbrella-shaped topography of the Island of Oahu the land shells have varied from common ancestral coastal type to valley-cradled, differentiated varieties in the upper and disjointed valleys of this dismantled, volcanic island cone."*

The limits of this address do not permit us to treat at length of the wonderful changes, both geological and zoological, which occurred in western America during the Tertiary. They are now familiar to every one. The geological changes were very great and widespread, as shown by the elevation of the land at the close of the Miocene. Fragments of the Cretaceous sea-bottom, with horizontal strata, occur in the Rocky Mountains at a point about 10,000 feet above the sea. The inland Cretaceous sea was drained off and replaced by a series of fresh-water lakes, beginning with the Puerco, or the lowest Eocene, and ending with the Pliocene lakes.

The most salient biological features of the Tertiary are the apparently sudden appearance, all over the world, of placental mammals, ending, if the deposits are truly Pliocene, with the Java Pithecanthropus, and at the beginning of the Quaternary with paleolithic man.

The question here arises as to what retarded the progress in the mammalian types, although small, generalized, feeble insect-eaters had originated certainly in the Triassic and probably as early as the end of the Permian. We can only account for it by the unfavorable biological environment, by the apparently overwhelming numbers of Mesozoic reptiles, adapted as they were for every variety of station and soil, whether on land, in the ocean, in the lakes and rivers, and even in the air.

When the reptiles became partly extinct a great acceleration in the evolution of mammals at once resulted. There were now upland grassy plains, bordered by extensive forests, which also clothed the highlands, and all the geographical conditions so favorable to mammalian life became pronounced after the Cretaceous seas were drained off.

In his admirable essay on the relation between base-leveling and organic evolution, which we had not read until after planning and writing this address, though following the same line of thought, Mr. J. B. Woodworth suggests that mammalian life in the Mesozoic was unfavorably affected by the peneplain and by reptilian life.

"The weak marsupials or low mammals, which appear in this country with Dromatherium in the tolerably high relief of the Trias, were apparently driven to the uplands by the more puissant and numerous reptilia of the peneplain. Their development seems also to have been retarded." Again he says: "To sum up the faunal history of the Mesozoic alone, we have seen that *pari passu* with the creation of broad lowlands there was brought on to the stage a remarkable production of reptiles, a characteristic lowland life; and we note that the humble mammalia were excluded from the peneplain or held back in their development, so far as we know them by actual remains, during this condition of

*The Relation between Base-leveling and Organic Evolution, referring to J. T. Gulick's article in Proc. Bost. Soc. Nat. Hist., XXIV., 1870, pp. 166-7.

affairs until the very highest Cretaceous. At the close of the Mesozoic the area of the peneplain was uplifted and there came into it the new life. Not only the changed geographic conditions, but the better-fitted mammalia, also were probably factors in terminating the life of the peneplains."*

After the placental mammals once became established, as the result of favorable geographical conditions, of migrations, isolation, and secondarily of competition, the evolution as well as the elimination of forms, as is well known, went on most rapidly. Remains of over two thousand species of extinct mammals during Tertiary times which existed in America north of Mexico have been already described, where at present there are scarcely more than three hundred. This process of specialization involved not only the lengthening of the legs, the change from plantigrade to digitigrade, and to limbs adapted for seizing and handling their prey or food, or for swimming and climbing; the reduction of digits; the evolution of armatures, protective scales, etc.; but, above all, an increase in the mental capacity of the later forms, not only of mammals, but of birds, as shown by the progressive increase in size of their brains; those of certain existing mammals being eight times as large, in proportion to the bulk of the body, as those of their early Tertiary ancestors. This, of course, means that animal shrewdness, cunning and other intellectual qualities, the result of semi-social attrition and competition, had begun to displace the partly physical factors, and in the primates these may have in the beginning led to the appearance of man, a social animal, with the power of speech, and all the intelligent moral and spiritual qualities, which perhaps primarily owe their genesis to increased brain-power.

* *American Geologist*, Vol. XIV., Oct., 1894, pp. 208-235.

The three most specialized types of mammals below men are the horse, the bats and the whales. In the case of the bats, which appear in the Eocene, Nature's experiment with these mammalian aëronauts succeeded to the extent that they still exist in small numbers. Late in the Cretaceous, or very early in the Eocene, competition apparently forced some unknown carnivorous type to take up an aquatic life, and the great success of the incoming cetacean type, resulting in the Eocene zeuglodonts and Miocene Squalodon, may have had an influence on the final extinction of the colossal marine reptiles.

6. THE QUATERNARY PERIOD.

Coming now to the glacial epoch of the Quaternary period, we plainly see that, under the extreme conditions to which as never before, life in the northern hemisphere was exposed how intimate are the relations of geology and biology.

The rise of land at the beginning of the Quaternary, which carried the land and the life on it up into a cooler zone, with a mean temperature so low that the snows remained from century to century unmelted, forming continental glaciers, excited an immediate influence on the life. There were very soon developed a circumpolar flora and fauna, originating from the few Pliocene forms which became adapted to climatic conditions more extreme than ever before known in the world's history. While a few forms thus survived, some must have perished, though the bulk of them migrated southward.

The story told by the Port Kennedy hole, in Pennsylvania, just south of the limits of the ice sheet, is a most striking one. In that assemblage where are intermingled the bones of mammals of the Appalachian subprovince, with certain extinct forms, and those of the tapir and peccary and colossal sloths,adapted to the warmth of the Pliocene

and of the present Central American region, we can realize as never before the immediate effect of a simple though very decided change of climate on organic life.

As a result of the submergence of the land in the north Atlantic and Arctic regions during the Leda or Champlain epoch succeeding, and the consequent amelioration of the climate, there was a return of a portion of the Pliocene species to the vast area thus freed from the presence of land ice.

Another effect of change of climate due to the further upheaval, drainage and drying up of lakes and river sources in the central portions of all the continents was the destruction of forests resulting from the drying-up of the lakes and streams, the formation of vast internal desert regions, with the desert floras and fauna and saline animals peculiar to them ; these are the last steps in geological history of the origination of species, and have been taken almost under the observation of man. In the origin of species adapted to desert areas and to salt lakes, *faunæ relictæ* of the lakes on the elevated plains of Asia, South America, Africa, Sweden and the Great Lake region, we see that geographical isolation and the absence of competition are the primary factors in the case.

In conclusion, it is, from the nature of the case, notwithstanding the imperfection of the geological record, apparent that the fullest, most complete and convincing proof of organic evolution is derived from the past history of life, from paleontology, which involves the fact of geological succession. Looking back for half a century we see that organic evolution is a fact and is grounded and dependent on geological evolution, and the latter on cosmical evolution. Should we ever have to abandon the principle of evolution we should also have to give up the theory of gravitation, the principle of the correlation of physical forces, and also the conception of the unity of nature. All of these principles are interdependent, and form the foundation stones of our modern science.

The rapid summary we have given of the successive changes and revolutions in the earth's history and the fact that they are accompanied or followed by the process of the extinction of the unadapted, and their replacement by the more specialized and better adapted, show that there is between these two sets of phenomena a relation of cause and effect.

Moreover, it cannot be denied that the formation of our solar system in the manner outlined by the founders of the nebular hypothesis, that the progressive changes in geology and the earth's topography, the gradual building-up or evolution of the continents, and the increasing fitness and intelligence of the life on its surface, the final outcome being man, whose physical development was practically completed at the beginning of the Quaternary period, and whose intellectual and moral improvement have, as it were, but just begun—the scientist, as such, can scarcely deny that this process of evolution, along so many lines and involving not only material but mental and moral advances, has gone on in an orderly and progressive way. The impression left on the mind is that all these changes, inorganic and organic, have been purposive rather than fortuitous, the result of the action of natural laws, impressed on matter by an Intelligence and force outside of, but yet immanent in, all things material.

With Hutton, we may say: "We have now got to the end of our reasoning ; we have no data further to conclude immediately from that which actually is. But we have got enough—we have the satisfaction to find that in Nature there is wisdom, system and consistency."

Here, as men of science merely, we may pause and confess our ignorance of the first or ultimate cause of this progressive evolutionary movement pervading the material

universe and, suspending our judgment, assume an agnostic position. But the human mind, even when rigidly scientific and logical, is so constituted that few of us are satisfied to stop here. He who is most capable of daring speculation in the realm of physical or biological or philosophic thought cannot refrain from inquiring into the nature of the first or moving cause, and how the present order of things has been brought about.

As a mere working hypothesis, we are, at least many of us, compelled to assume that the present order of things, material and immaterial, is not self-evolved, but is the result of an Infinite Intelligence and Will giving the initial impulse and dominating as well as guiding and coordinating the progressive changes, whether cosmical, geological or biological. The fact of the survival of the fittest, of the extinction of the unfit, the conclusion that throughout the universe order has arisen from chaos or the undifferentiated, the specialized from the generalized, that the good and beautiful and true have in the past overcome and will continue to outweigh what is unfit and evil in matter, mind and morals, at least strongly suggests that the First Cause is not only omnipotent but all-wise and beneficent. For evolution tends to optimism. Few working biologists are pessimistic. And thus, while science as such is concerned with facts and their relations, we can at the end of this century of scientific effort affirm that it need not be, and is not, opposed to whatever is noble, exalted, hopeful and inspiring in human aspirations, or to the yearnings of the soul for a life beyond the present, for there certainly are, in the facts of the moral and spiritual evolution of our race, intimations of immortality, and suggestions, where absolute proof is naturally wanting, of a divinity that shapes the course of nature.

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REPORTS OF COMMITTEES OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SIXTEENTH ANNUAL REPORT OF THE COMMITTEE ON INDEXING CHEMICAL LITERATURE.

THE Committee on Indexing Chemical Literature respectfully presents to the Chemical Section its sixteenth annual report, covering the twelve months ending August, 1898.

Works Published.

A Bibliography of the Metals of the Platinum Group, Platinum, Palladium, Iridium, Rhodium, Osmium, Ruthenium, 1748–1896. By JAS. LEWIS HOWE. Smithsonian Miscellaneous Collections, 1084. City of Washington, 1897. 8vo. Pp. 318.

This fine volume forms one of the most valuable and comprehensive indexes to an important field of chemical literature produced under the auspices of the Committee since its appointment in 1882. It shows on every page evidence of conscientious and critical skill; the author- and subject-indexes, with which the book concludes, are important features. Its workmanship and the method of presentation of data in type make Dr. Howe's volume a model.

Reference to the Literature of the Sugar-Beet, exclusive of works in foreign languages. By CLARIBEL RUTH BARNETT. U. S. Department of Agriculture. Library Bulletin, June, 1897. 4to. Pp. 9.

This carefully edited contribution to the bibliography of a subject interesting to the chemist as well as to the scientific farmer manifests the activity of the U. S. Department of Agriculture in its Library.

A Chemical Bibliography of Morphine 1875–1896. By H. E. BROWN, under the direction of A. B. PRESCOTT. Completed in Pharmaceutical Archives, Vol. 1, No. 3.

A supplement carries the literature through 1897. The separates contain an index of authors.

A Bibliography of the Metallography of Iron and Steel. By ALBERT LADD COLBY. Published in the *Metallographist*, Vol. 1, No. 2, pp. 168–178. April, 1898.

This includes 188 titles, arranged alphabetically by authors, and numbered chronologically; it is reprinted, extended and re-arranged from *The Iron Age*, January 27, 1898, by the author.

Review and Bibliography of the Metallic Carbides. By J. A. MATHEWS. Smithsonian Miscellaneous Collections, No. 1090. City of Washington, 1898. 8vo. Pp. 32.

Published by the Smithsonian Institution on recommendation of this Committee. Under each metal forming a carbide the author has given a brief synopsis of the chemical data with references to the literature on that subject. There is an author-index.

A Catalogue of Scientific and Technical Periodicals 1665–1895, together with Chronological Tables and a Library Check-List. By HENRY CARRINGTON BOLTON. Second Edition. Smithsonian Miscellaneous Collections, No. 1076. City of Washington, 1897. 8vo. Pp. 1247.

This bibliography was first issued in 1885 and the second edition has been prepared at the request of the Smithsonian Institution. It embraces periodicals in every department of pure and applied science, including, of course, chemistry and chemical technology. The Chronological Tables give the date of publication of each volume of about 550 periodicals; they enable one to ascertain the date of a given volume in a given series of a given work, or to determine the number of a volume when the date only is given. The Library Check-List shows in what American Libraries, 133 in number, complete sets of the periodicals may be found. The second edition brings the date down to 1895; its publication has been delayed by the compilation of the Check-List. The periodicals catalogued number 8603.

Alkaloidal Estimation: a bibliographical index of chemical research prepared from original literature for the Committee of Revision and Publication of the Pharmacopœia of the United States of America, 1890–1900. By PAUL I. MURRILL, under the direction of ALBERT B. PRESCOTT. Ann Arbor, 1898.

A pamphlet of about sixty pages, not for sale.

The *Review of American Chemical Research*, edited by ARTHUR A. NOYES and published in the Journal of the American Chemical Society, completed Vol. III., in December, 1897. Two indexes, an author- and a subject-index, increase its value

Mr. E. W. Allen, Acting Director of the Office of Experiment Stations, U. S. Department of Agriculture, in reply to inquiries, sends the following communication:

"During the past year we have completed Volume IX. of the Experiment Station Record (1897–'98). This, like former volumes, contains abstracts of and references to articles on the methods and results of work in agricultural chemistry published in this country and in Europe. During the past year the review of Russian scientific periodicals has been added. About 2,000 cards of the Card Index of Experiment Station Literature have been issued during the past year, making a total of 16,000 cards in this index at present. In addition to several accounts of chemical studies of the nutrition of man, the Office has issued a 'Report of preliminary investigations on the metabolism of nitrogen and carbon in the human organism with a respiration calorimeter of special construction,' by W. O. Atwater, C. D. Woods and F. C. Benedict, the work being carried on in part by funds furnished by this Office. In this connection may also be mentioned a compila-

tion of over 400 pages of metabolism experiments in which the balance of income and outgo was determined, made by W. O. Atwater and C. F. Langworthy, and issued from this Office. The bulletin is a digest of about 3,600 experiments with man and animals in which the balance of one or more of the factors of income and outgo was determined. While this work may at first thought seem somewhat afield, it is chemical in its character as well as physiological, and has involved in some cases quite extensive chemical studies."

The 'Digest Metabolism Experiments' herein named forms Bulletin No. 45 of the Office of Experiment Stations, and constitutes a comprehensive bibliography of the subject.

The Committee chronicles the publication of the following bibliographies bearing more or less on chemical researches:

Contributions to the Bibliography of Gold. By A. LIVERSIDGE. Australasian Association for the Advancement of Science. Brisbane, 1895. 8vo.

Analyst (The). The organ of the Society of Public Analysts. *General-Index* to the Proceedings of the Society of Public Analysts, Vol. I. (1876), and to the Analyst, Vols. I.–XX. (1877–1896). Compiled by J. CUTHBERT WELCH. London, 1897. 8vo. Pp. i+181.

Arranged on the dictionary plan, authors, subjects and cross-references in a single alphabet.

Bibliographie des travaux scientifiques (sciences mathématiques, physiques et naturelles) publiés par les Sociétés Savantes de la France. Par J. DENIKER. Tome I, part 2. Paris, 1897. 4to.

Part 1 was published in 1895. Most important for original papers published in France.

Biographisch-Literarisches Handwörterbuch zur Geschichte der exacten Wissenschaften. Von J. C. POGGENDORFF. Dritter Band (die Jahre 1858 bis 1883 umfassend). Herausgegeben von B. W. Feddersen und A. J. von Oettingen. Leipzig, 1897–98. Roy 8vo.

This valuable addition to Poggendorff's well-known biographical dictionary is useful to chemists inasmuch as it gives the titles of original papers by the principal chemists of the world published during the period specified.

Works in preparation and reports of progress.

A subject- and author-index to the first twenty volumes of the *Journal of the American Chemical Society* is being compiled by Mr. Sohon, who expects to complete the MS. in December, 1898.

A First Supplement to the Select Bibliography of Chemistry, 1492-1897, by Henry Carrington Bolton, is now going through the press. It will form a volume of the Smithsonian Miscellaneous Collections of about 600 pages.

A Second Supplement to the same bibliography, to contain chemical dissertations only, is well advanced, about 8,000 titles being already in hand.

Dr. A. C. Langmuir reports the completion of his MS. *Index to the Literature of Zirconium.*

Dr. C. H. Joüet reports the near completion of his *Index to the Literature of Thorium.*

Mr. George Wagner reports progress on a *Bibliography of Oxygen.*

The manuscript of an *Index to the Literature of Thallium,* 1861–1896, by Miss Martha Doan, lately of Cornell University, was submitted to the Committee through Professor L. M. Dennis, and after critical examination it has been unanimously recommended to the Smithsonian Institution for publication.

Dr. Alfred Tuckerman is engaged upon new editions of his *Indexes to the Literature of the Spectroscope,* and of *Thermodynamics,* which are to be continued to the year 1900.

He also reports progress on the *Index to the Mineral Waters of the World*, the printing of which has been delayed by mechanical difficulties.

Dr. Wilhelm P. Jorissen, of Rotterdam, has undertaken to bring down to date Professor Albert R. Leeds' *Indexes to Ozone and to Hydrogen Peroxide*, first issued in 1880, and long since out of print.

Monsieur Jules Garçon, chemical engineer (of 40 *bis* Rue Fabert, Paris), is about to publish an important contribution to the bibliography of technical chemistry, entitled: 'Répertoire universel de bibliographie des industries tinctoriales et des industries annexes.' It is expected to form three large volumes. In the preparation of this immense undertaking the author has examined 1,800 works and 111 sets of periodicals, the latter in 5,000 volumes, besides 7,000 other articles and documents. Subscriptions (100 francs) may be sent to the publishers, Gauthier-Villars et fils, Paris. M. Garçon is known as the author of the 'Bibliographie de la technologie chimique des fibres textiles,' Paris, 1893, noted in our Thirteenth Annual Report.

Two unfinished manuscript indexes are at the disposal of persons willing to undertake their completion: an *Index to the Literature of Carbonic Oxid*, begun by the late Professor William Ripley Nichols and continued by Professor Augustus H. Gill; and an *Index to the Literature of Milk*, begun by Professor Clement W. Andrews.

As stated in previous reports, this Committee does not attempt to prescribe a fixed plan for volunteer indexers, but leaves method and topic to be chosen by compilers; the Committee does not seek to control the productions further than to insure work of high merit and to guard the interests of the Smithsonian Institution, which has agreed to publish manuscripts endorsed by the Committee. Chemists willing to undertake the compilation of indexes are requested to send their names and addresses with a memorandum of the subject chosen to the Chairman of the Committee (Cosmos Club, Washington, D. C.), who will furnish sample copies of indexes and other information.

H. Carrington Bolton, *Chairman*,
F. W. Clarke,
A. R. Leeds,
A. B. Prescott,
Alfred Tuckerman,
H. W. Wiley, *Committee.*

REPORT OF THE COMMITTEE ON STANDARDS OF MEASUREMENT.

The determination of the mechanical equivalent of heat by the electrical method, as reported by Griffiths (*Phil. Trans.*, A, 1893) and by Schuster and Gannon (Proc. Roy. Soc., Nov., 1894) gave a larger value than Rowland's corrected result. This fact has created a demand for the redetermination of the ampere in terms of the electrochemical equivalent of silver. At the Toronto meeting of the British Association last year a grant was made to the B. A. Committee on Electrical Measurements for the purpose of carrying out this investigation.

At the Detroit meeting of this Association the grant of $50 previously made for the use of this Committee was made available for the past year. Though this appropriation was clearly insufficient for the purpose, it was decided that the redetermination of the ampere should be undertaken for the committee of this Association in the physical laboratory at Ann Arbor. The work has been ably carried to completion by Professor Patterson and Dr. Guthe. The details of the method will be given in a paper by Dr. Guthe before Section B.*

The discrepancy between Griffiths' results and those of Rowland is about one part in 400 at all temperatures between 15° and 25° on the nitrogen scale. Those of

* This paper was duly presented.—Ed. Science.

Schuster and Gannon exceed Rowland's at 19.°1 on the same scale by about one part in 500 (Johns Hopkins University Circulars, June, 1898). These differences exist after the final elaborate comparison of thermometers and the reductions to the same absolute scale of temperature.

Since the electrical methods employed to determine the mechanical equivalent of heat involve either the current and the E. M. F. of the Clark cell or the square of this E. M. F., and since the E. M. F. of the Clark cell is determined by means of the silver voltameter it is evident that the current enters the final result as the square. If the discrepancy is due entirely to an error in the value of the ampere, assuming the ohm to be correct, then the ampere should be one part in 1,000 to one part in 800 larger than the present accepted value. That is, the electro-chemical equivalent of silver should be increased from Lord Rayleigh's value of 0.001118 to 0.0011191 or 0.0011194. Lord Rayleigh does not claim for his result an accuracy greater than one part in 1,000.

The method used by Patterson and Guthe was that of a specially constructed electrodynamometer of large dimensions, and the employment of the torque of a phosphorbronze wire to equilibrate the countertorque due to the effort between the magnetic fields of the stationary and movable coils. This method eliminates entirely the value of gravity g. The torque of the wire was measured by observing the period of vibration of a cylindrical brass weight of known mass and dimensions when suspended by the phosphorbronze wire. The entire success of this part of the investigation was due to the fact that the observations were made with the whole apparatus enclosed in a fairly good vacuum. Under these conditions the vibrations could be followed for hours at various intervals; the logarithmic decrement was almost entirely constant, and it was easy to obtain a curve connecting temperatures and periods of vibration as a torsional pendulum. The wire was so connected to the support and to the brass cylinder that it could be transferred from the vacuum apparatus to the electrodynamometer and back again without disconnecting it from the terminal pins. From personal inspection at the several stages of the investigation assurance can be given that the work has been most carefully executed at every point, and all known sources of error have been as completely eliminated as possible. The weights employed were compared with the standards at the U. S. Bureau of Weights and Measures in Washington; the standard of length was a halfmeter bar of speculum metal made for the University of Michigan by the late Professor W. A. Rogers. The time was taken from a standard Riefler clock checked by comparison with the observatory time. The result of the investigation is that the electro-chemical equivalent of a used solution of neutral silver nitrate, fifteen parts by weight of the silver salt to eighty-five parts of distilled water, is 0.0011192 gm. per ampere per sec. This exceeds Lord Rayleigh's value by by about $\frac{1}{9}$ of one per cent. and causes the discrepancy in the mechanical equivalent of heat to disappear.

The corresponding change in the E. M. F. of the Clark cell will be from 1.4342 to 1.4327 at 15° C. A direct determination has not yet been made and this redetermination is reserved for the coming year.

Dr. Kahle has obtained for the electrochemical equivalent of silver the value 0.0011182 (*Wied. Annal.*, Vol. 59, p. 532) by the use of an electro-dynamometer designed by von Helmholtz and a *fresh* solution of the salt. Pellat and Potier found the same value as that of Patterson and Guthe (*Journ. de Phys.* 9, p. 381, 1890).

HENRY S. CARHART,
Secretary of Committee.

ANN ARBOR, MICH., July 25, 1898.

CURRENT NOTES ON ANTHROPOLOGY.

INITIATION CEREMONIES IN AUSTRALIA.

THE *bora* is the ceremony in many Australian hordes by which the boy is introduced into manhood. It has been described many times, by no one more sympathetically than by Mr. A. B. Howitt, who inherited the literary talent of his distinguished parents, William and Mary Howitt.

No description of it, however, has heretofore been offered of its ceremonial as practiced on the table land of New South Wales and that neighborhood. This is presented by Mr. R. H. Mathews in the *Proceedings* of the American Philosophical Society for July, 1898 (No. 157). It there bears the name *bŭrbŭng*. He explains the ritual with much minuteness, and adds a map on which is defined the boundaries of the several districts within which each type of ceremony is in force. He adds an appendix on the *nguttan*, an abbreviated initiation rite practiced by some tribes.

THE TARASCAN LANGUAGE.

THE language known as Tarascan is spoken by the natives of the State of Michoacan. Its words are long, vocalic and sonorous. Previous to the Conquest the Tarascans were a semi-civilized people, city-builders, agricultural and peacefully inclined.

An 'Arte' of their tongue written by Father Gilberti was printed in Mexico in 1558, and now belongs among the rarest of Americana. Dr. Nicolas Leon, formerly Director of the Michoacan Museum, has accomplished an acceptable work to students of such subjects by editing a nearly facsimile edition of it (Mexico, 1898, pp. 344). He deserves the greatest credit for its accuracy. A limited number of copies have been placed on sale with the house of Hiersemann, Leipzig.

ANTHROPOLOGICAL PESSIMISM.

THERE has been a curious tendency during the last decade among European anthropologists toward scientific pessimism. Numerous writers, such as Le Bon, Lapouge, Ribot, Nordau, Vierkandt, Nadaillac, etc., have deplored the traits of modern culture and seen in many of them signs of degeneration. The white race is to be overwhelmed, Europe is to lose its prestige, modern society is to go to the bad. The Latin race is to fall before the Teutonic, the Teutonic before the Slavic, and so on. M. Novicou, in a book reviewed in the *Centralblatt für Anthropologie*, calls a halt to these lamentations. He argues that when racial, national and social jealousies cease, the species will be much better off; and what these scientific 'calamity howlers' are grieving about is precisely this advancement. (*L'avenir de la race blanche*, Paris, 1897.)

D. G. BRINTON.
UNIVERSITY OF PENNSYLVANIA.

NOTES ON INORGANIC CHEMISTRY.

A RECENT number of the *Zeitschrift für physikalische Chemie* contains two interesting investigations. The influence of various vapors on the luminosity of phosphorus has been long known; as that it is non-luminous in pure oxygen unless the pressure is reduced, that turpentine destroys the luminosity, etc. Herr Centnerszwer has experimented with a large number of substances. In the case of organic compounds he finds that in homologous series the influence increases with the number of carbon atoms, and is approximately the same for isomers. It increases with double linking of carbon atoms; is little affected by replacement of hydrogen by chlorin or bromin, but largely affected by iodin substitution. No clue is suggested to the cause of the phenomena.

THE second article is by M. Tanatar on the perborates. These are formed by the electrolysis of a concentrated solution of

sodium orthroborate, and also by treating the latter salt with hydrogen peroxid. The sodium salt, $NaBO_3$, $4H_2O$, and the ammonium salt, NH_4BO_3, H_2O were formed and while powerful oxidizing agents are quite stable. These are the only compounds of quintivalent boron known, though from the second method of formation the possibility of their constitution being NH_4 BO_2, H_2O_2, and $NaBO_2$, H_2O_2, $3H_2O$ would seem not to be excluded.

MUCH discussion has been occasioned by the announcement of the discovery of new gases in the atmosphere. Professor Berthelot calls attention in the *Comptes Rendus* to the fact that the green line of krypton almost exactly coincides with the green line of the aurora spectrum, and suggests that the element should, therefore, be called eosium. Dr. Arthur Schuster in *Nature* shows the spectrum of metargon to resemble closely that of carbon plus that of cyanogen. In replying, Professor Ramsay recognizes the great similarity, but produces evidence which seems to render it very improbable that any form of carbon could be present, as the metargon spectrum remains the same in spite of every effort to remove any possible carbon present either as an element or a compound.

THE element calcium has generally been described in text-books as a yellow metal. This color is evidently due to impurities, as M. Moissan has recently obtained pure calcium, in the form of brilliant white hexagonal crystals. The crystals were obtained by dissolving the metal in liquid sodium at a low red heat and removing the sodium by means of the cautious use of absolute alcohol. Calcium can also be obtained by the electrolysis of fused calcium iodid. Each of these methods yields a metal over ninety-nine per cent. pure.

IN the *Comptes Rendus* Moissan also shows that the metal calcium burns strongly in hydrogen forming a hydrid CaH_2, which is transparent, cystalline and stable. It is decomposed by water with great violence, hydrogen being evolved. It is not, like the the corresponding hydrid of lithium, decomposed by being heated in nitrogen. In order to distil pure lithium the metal must be kept in an indifferent gas, and for this purpose hydrogen or nitrogen will not serve, as lithium combines directly with both. The only gases which would be really indifferent would be argon and helium.

ACCORDING to *Nature* the latest statistics show a total of 6,144 chemical works in Germany, employing over 125,000 persons. In the Hamburg district 4,000 are employed, as compared with 1,300 ten years ago. This shows the rapid growth of these industries in Germany in the last few years, a fact which is attracting the attention of England and other countries as well.

J. L. H.

SCIENTIFIC NOTES AND NEWS.

COLOR-VISION.

MR. T. C. PORTER has given a communication to the Royal Society (presented by Lord Rayleigh and printed in the Proceedings, June 30) on the flicker phenomenon. He found, among other things, making use for this purpose of a cardboard disc half black and half white, viewed in the different colors of the spectrum of the second order of a Rowland's plane diffraction grating of 14,434 lines to an inch, that the greater the duration of the stimulation of the retina by the colored light the shorter the time during which it continued to be undiminished in amount, and that, with some exactness, one of these quantities is inversely proportional to the other. This inverse proportionality is known to hold between the brightness of the stimulus and its undiminished duration ; it is now seen that when the brightness is constant a longer period of exposure plays the same part as a greater luminosity as regards its undiminished continuance.

IT has been shown by Professor Albertoni that there is a close relation, in the de-

velopment of animals, between the rods and the pigment of the epithelium. In some animals both are formed before birth; in others both are formed after birth; in all, the pigment gets its full intensity only after birth, and in those born blind (kittens) only some days after they open their eyes. It would be interesting to find out if kittens pass through a period during these few days after their eyes are opened, when, although they can see by daylight, they are not yet provided with night-vision. Professor Albertoni does not distinctly say that the rods are destitute of the visual purple at this time, when the pigment of the epithelium is wanting, but it is very probable that that is the case.

C. L. F.

EXPERIMENTS WITH KITES AT BLUE HILL OBSERVATORY.

THE world's record for high kite flight was broken on August 26th at Mr. Rotch's observatory by Messrs. Clayton and Ferguson, who dispatched a tandem of kites into the air until the highest one reached an altitude of 12,124 feet above the sea level, a height 277 feet greater than any kite has reached heretofore.

The top kite was of the Lamson ribbed pattern, and had an area of 71 square feet. The other kites were the modified Hargreave box variety, and had a combined area of 149 square feet. All the kites were fitted with self-regulating, elastic bridles, invented at the observatory, to prevent the kites from exerting a dangerous pull. Five miles of line, weighing 75 pounds, was let out, while the weight of the kites, recording instruments and secondary line, was 37 pounds, making a total of 112 pounds lifted into the air. The recording instrument was made by Mr. Ferguson and was of aluminum, weighing three pounds, and registering temperature, pressure, humidity and wind velocity. The ascent was begun at 11 o'clock, and the highest point reached at 4:15 p. m.

The kites passed through clouds when about a mile above the surface of the earth, but while above the clouds the instruments showed the air to be very dry. At the highest point the temperature was 38 degrees and the wind velocity 32 miles an hour. At the ground at the same time the temperature was 75 and the wind velocity 32 miles. The highest wind velocity recorded was 40 miles an hour at a height of 11,000 feet. The wind on the ground at this time was from the west, while at the highest point reached by the kites it was southwest. The flight was one of a series of high ascents made during the spring and summer, averaging about a mile and a-half, while on several occasions a height of over 10,000 feet has been obtained.

THE PREVENTION OF CONSUMPTION.

WE learn from the *British Medical Journal* that the Congress of Tuberculosis, which came to an end on August 2d, passed the following resolutions: The Congress, considering that contagion constitutes by far the most important cause of human tuberculosis, and that sputa dried and reduced to dust are the most effective agents of contagion, makes the following recommendation: 1. That, until the time arrives when tuberculosis will be included among the contagious diseases the notification of which is compulsory, all places open to the public should be provided with hygienic spittoons, and with a conspicuous notice forbidding expectoration anywhere else than into these receptacles. 2. That the public authorities set the example by ordering the carrying-out of this measure with the least possible delay in all places under their jurisdiction, and especially in schools of every class; this is the most vital point in the reform. 3. That tuberculous patients should not be sent to convalescent homes open to persons suffering from other diseases. 4. That homes should be established and specially reserved for convalescent children. 5. That a 'medical committee of initiative' for the establishment of popular and gratuitous sanatoria should be formed. 6. That the private initiative of the medical body, and the initiative of the public imitating the example already set in France and in other countries, should lead to the creation of the largest possible number of sanatoria. 7. That the Minister of Public Instruction and the Department of Public Hygiene in the Ministry of the Interior encourage, by an official patronage, the courses of instruction in hygiene which the League against Tuberculosis

is now organizing in Paris in each *arrondissement*, with the idea of extending this movement to the other towns of France. 8. That the Permanent Committee of the Congress make an official application to the general management of the Universal Exhibition of 1900 to bespeak its interest in the work of prevention of tuberculosis by studying, in conjunction with the Committee, the form in which instruction should be given to visitors to the Exhibition as to the means whereby tuberculosis is contracted and can be avoided. 9. That periodical international meetings be held for the study of tuberculosis, especially its prophylaxis. 10. That governments should endeavor to devise means of preventing or repressing the fraudulent use of tuberculin for the purpose of concealing the existence of tuberculosis in animals intended for sale or exportation. The Congress, further, considering that the constant increase of tuberculosis of bovine animals gravely threatens public health and wealth, and that contagion is the sole truly efficient cause of this increase, affirms the urgent necessity of legislative measures enjoining (*a*) the separation of diseased from healthy animals; (*b*) the prohibition of the sale of diseased animals for butcher's meat; (*c*) the supervision of cowhouses devoted to the production of milk intended for public use as food, and the immediate slaughter of every cow affected with tuberculous mammitis; (*d*) the sterilization or at least the pasteurization of milk intended for the production of butter and cheese on a large scale; (*e*) the generalization of the service of inspection of butcher meat on a plan more or less analogous to that which has been in operation in Belgium for several years.

GENERAL.

PROFESSOR KOCH is at present engaged in the study of malaria in the hospitals of Milan, and expects to make a special investigation of the subject in Italy.

A DINNER, at which Lord Lister will preside, will be given to Professor Virchow on October 5th, on the occasion of his visit to London to deliver the second Huxley lecture.

THE Americans in attendance at Cambridge at the Congresses of Zoology and Physiology were Professors Bowditch and Porter, of Harvard; Professors Osborn and Lee, of Columbia; Professors Marsh and Lusk, of Yale; Professor Mark, of Harvard; Professor Baldwin, of Princeton; Professor Jastrow, of Wisconsin; Professor Lombard, of Michigan; Professor Watase, of Chicago; Professor Atwater, of Wesleyan, and Dr. Stiles, of the United States Department of Agriculture.

PROFESSOR WILLIAM JAMES, of Harvard University, is at present giving lectures on the Pacific Coast. These include an address before the Philosophical Union of the University of California, which, under the direction of Professor Howison, is doing much for the advancement of philosophy in America.

DR. ARNOLD GRAF, the author of valuable contributions to morphology, died in Boston on September 3d, aged thirty years. A notice of his scientific work will follow:

DR. JOHN HOPKINSON, the well-known English electrical engineer, was killed by an Alpine accident, on about August 28th. The cablegram conveying this information states that his son and two daughters were also killed, the party having apparently fallen over a precipice while ascending one of the high Alps without a guide. Dr. Hopkinson, born in 1849, was a graduate of London and Cambridge. He was elected Fellow of the Royal Society in 1878 and was elected President of the Institution of Electrical Engineers in 1890 and again in 1895. He had contributed important scientific papers to the *Transactions* of the Royal Society, but is best known for his inventions in the application of electricity. Dr. Hopkinson was intending to visit America during the coming autumn.

WE regret also to record the following further deaths among men of science abroad: Mr. J. A. R. Newlands, who in 1887 was awarded the Davy Medal of the Royal Society, in recognition of his discoveries regarding the periodic relations between the atomic weights of the elements; M. J. M. Moniz, the naturalist, who died at Madeira on July 11th, and M. Pomel, a mining engineer, who made important contributions to our knowledge of the Sahara.

WE were compelled to record some time since the regretable fact that M. Grimaux, the eminent French chemist, had been forced to

retire from his chair in the École Polytechnique, owing to his sympathy with the protests against the scandals in the French army and courts. M. Grimaux was elected President of the French Association for the Advancement of Science two years ago, but when he attempted to deliver his address at Nantes he was interrupted by noisy demonstrations, countenanced apparently by the mayor, to such an extent that he was unable to proceed. The address was subsequently delivered in a schoolhouse, from which the public was excluded, and M. Grimaux did not even venture to preside at the closing meeting of the Association.

THE screw schooner *Godthaab* left Copenhagen on August 16th for Angmagsalik, in East Greenland, with an expedition under First Naval Lieutenant Amdrup. The expedition, which has been fitted out by a scientific institute at a cost of 150,000 kroner, is provisioned for two years. Its object is to explore the east coast of Greenland between the 66th and 70th degree north latitude, with Angmagsalik as its starting point.

THE steam whaler *Fridtjof*, having on board Mr. Walter Wellman and the members of the expedition to Greenland, has returned to Norway after landing an expedition at Cape Tegetthoff, on the southern part of Hall's Island. While the Wellman party were returning they met the expedition to Franz Josef Land under Dr. A. G. Nothorst at Koenigskar Island, and were informed that all search for Andrée had proved futile.

A NEW photographic telescope for the Cambridge Observatory is now finished at the works of Sir Howard Grubb. As the buildings are also finished, it is expected that the telescope will soon be in use.

A GRANT of £250 was made by the British government from the Royal Bounty Fund toward the expenses of the International Congress of Zoology.

IT appears from a recently-issued Blue Book that the visitors to the Natural History Museum, in London, in 1897, numbered 422,607, as against 453,956 in 1886. The attendance on Sundays was well maintained, nearly 50,000 persons having, in the course of the year, availed themselves of the privilege afforded them. The average daily attendance for the year was: For all open days (including Sundays), 1,167; for week-days only, 1,203; and for Sundays, when the Museum is open only during part of the day, 956.

IN the course of last year 26,029 volumes and pamphlets (including 124 atlases and 1,355 books of music) were added to the library of the British Museum, of which 5,962 were presented, 12,175 were received in pursuance of the laws of English copyright, 718 by colonial copyright, 480 by international exchange, and 7,594 acquired by purchase.

THE *Southern Cross*, fitted out by Sir George Newnes for Antarctic exploration under Mr. Borchgrevink, has left London for Hobart Town. The expedition, which is well equipped for scientific work, is expected to return in 1900.

THE steamship *Hope* arrived at St. Johns, N. F., on August 27th. It is reported that after leaving Sydney, C. B., the first landing was at Cape York, where Esquimaux could not be found. The expedition then sailed for Snow Pocket Bay, but here, again, they were disappointed. They then proceeded to Saunders Island, finding the natives there in poor condition. The *Hope* took on board a number of Esquimaux and sailed for Whale Sound, but owing to the heavy ice pack was unable to get in. She came out without serious injury. The party then decided to return to Saunders Island and spent a fortnight there. Then the *Hope* proceeded for Foulkefiord, meeting the *Windward* on the way. The latter is said to be a poor ship for this work, being unable to steam to any advantage. At Foulkefiord the *Hope* parted with Lieutenant Peary and sailed south on the 13th ult., the *Windward* leaving at the same time for Sheard Osborne Fiord, where Lieutenant Peary will make his headquarters during the winter.

IT will be remembered that at the time of the celebration of the centenary of the discovery of vaccination in 1896 it was decided to erect some permanent memorial to Jenner in Great Britain. The name of the British Institute of Preventive Medicine has been changed to the Jenner Institute of Preventive Medicine, and it

is proposed to collect £100,000 for the endowment of research in the Institute. The subscriptions include £5,000 from Lord Iveagh; £2,000 from the Earl of Derby; £600 from the Duke of Westminster, who, it will be remembered, assisted the Institute to obtain the site which its new building now occupies on the Chelsea Embankment; £100 from Lord Lister, and £200 from Mr. Alfred de Rothschild. Donations and subscriptions may be sent to the Honorary Treasurer of the Jenner Memorial Fund, Sir Henry E. Roscoe, 10, Bramham Gardens, London, S.W.

Nature states that the proposal made at the Toronto meeting of the British Association last year for a marine biological station in the Dominion of Canada is taking practical shape. Professor Prince, the Dominion Commissioner of Fisheries, reported at length upon the necessity for such a marine station for Canada in the Marine and Fisheries Blue Book, 1894; and the Royal Society, of Canada, also urged the importance of the matter; but it was not until the British Association appointed a committee, consisting of Professor E. E. Prince (Ottawa), Chairman; Professor Penhallow (Montreal), Secretary, and Professor A. B. Macallum (Toronto), Professor John Macoun (Ottawa), Professor Wesley Mills (Montreal), Professor E. W. MacBride (Montreal), and Dr. W. T. Thiselton-Dyer, that active steps were taken to carry out the scheme. An influential deputation waited upon the Hon. Sir Louis Davies, Minister of Marine and Fisheries, in April last, and during the recent sessions of the Canadian Parliament a vote of £3,000 was practically sanctioned, £1,400 being granted for the year 1898–99. A Board of Management has been chosen as follows: Professor E. E. Prince (nominated by Sir Louis Davies to represent the Department of Marine and Fisheries), to act as Director; Professors Penhallow and MacBride (McGill University), Ramsey Wright (Toronto University), L. H. Bailey (New Brunswick University), Rev. F. A. Huart (Laval University, Quebec), and members from Queen's University, Kingston, and Dalhousie University, Halifax, Nova Scotia.

IT is officially announced that there were 2,300 deaths from the plague during the last week of August in the Bombay Presidency. The epidemic is spreading, and there has been a fresh outbreak in the state of Hyderabad.

WE regret to note that the will of the late Adolph Sutro, who bequeathed valuable property in San Francisco for charitable and educational purposes, will be contested.

MESSRS. D. APPLETON & CO.'s announcements for August and September include 'The Earth and Sky,' by Professor Edward S. Holden, and 'Philip's Experiments, or Physical Science at Home,' by Professor John Trowbridge, of Harvard University.

WE have received from the American Entomological Society a reprint, from the twenty-fifth volume of their *Transactions*, of the bibliographical notice of George Henry Horn, by Philip P. Calvert. A portrait of Dr. Horn forms the frontispiece of the pamphlet. There is included a chronological list of his entomological writings, compiled by Mr. Samuel Henshaw, who also contributes an index to the genera and species of Coleoptera described and named in the 265 papers.

WE learn from *Nature* that many Polish men of science have signed a protest against the action of the Prussian authorities at Posen (Poznan) in prohibiting them from attending the meeting of the Polish Association for the Promotion of Medical and Natural Knowledge, which it was proposed to hold in that town at the beginning of August. Early in July the organizing committee of the meeting was informed by the Director of Police that persons of Polish nationality would not be permitted to take part in the proceedings, and that if they went to Posen they would be expelled from the country immediately. For thirty years the Association has held its meetings without any difficulties, and in the year 1884 a meeting was held in the town of Posen itself. The recent action, directed as it was against men whose only object was calm and friendly intercourse, violates the legitimate claims of science and discourages scientific investigation in Poland. It is unfortunate that intellectual enterprise should be made to suffer on account of strained relations between certain members of German and Polish nationali-

ties. The protest against the measures taken by the Prussian police authorities has been signed by most men of science in Cracow and Lemberg, and forwarded to the Polish members of the Austrian Parliament.

Nature states that efforts are being made to secure for the Maidstone Museum and Public Library the collection of prehistoric flint implements formed during the past thirty-four years by Mr. Benjamin Harrison, and illustrating important periods in the early history of man in Great Britain and elsewhere. It is proposed to select, from the specimens in Mr. Harrison's collection, the type series chosen from the chalk plateau implements by Sir Joseph Prestwich to illustrate his monographs upon the subject of plateau or eolithic implements, and other type implements which have been figured and described by other writers; a series to show variety of form and the probable uses to which these implements have been put; a collection of paleolithic implements from gravels in the West Kent district; and type series of neolithic implements found in Kent. The Maidstone Museum is situated in the immediate vicinity of the district in which they were discovered. An appeal for subscriptions to purchase the collection, signed by the Mayor of Maidstone, has been issued by the Museum Committee and nearly £100 have been subscribed.

THE *British Medical Journal* states that during the first few years after the foundation of the Anticharbon Institute at Turin the number of tubes of anticharbon vaccine sent out was only 4,000 to 5,000 a year. Professor Pagliani, then Director of the Public Health, decided that the Laboratory, which had been founded at Turin by Perroncito, should be removed to Rome. Immediately after this the production of vaccine greatly increased, as it was found possible to reduce its price. In the disorganization which overtook the Department of Public Health two years ago this laboratory came to grief; fortunately, however, its work was taken up by the Sero-therapeutic Institute of Milan, from which the vaccine continues to be sent out under the supervision of Professor Airoldi, a former assistant of Perroncito. Now the yearly output of anticharbon vaccine amounts to 165,000 tubes. From May 1, 1897, to April 30, 1898, sufficient vaccine was sent out to inoculate 33,734 bovine and 98,792 ovine animals. Anthrax has greatly diminished in Italy in recent years; but, in spite of the large amount of anticharbon serum supplied, a good many cases still occur, both among animals and among men, in different parts of the country.

THE Committee appointed by the Board of Trade, a year ago, to consider and advise upon the means of obtaining and publishing information as to opportunities for the introduction and development of British home trades in the various districts in which we have official representatives have adopted their reports. According to *Nature* it is suggested that the most economical course would be to send out experts periodically to make inquiries and to report upon the progress and the direction of trade. The Committee recommend the establishment of an office whose function it shall be to meet the constantly-increasing demand for prompt and accurate information on commercial matters, so far as it can be met by government action. Amongst the duties of this new office would be: (1) To collect and focus existing information upon any subjects of commercial interest, whether derived from official or from unofficial sources, and whether relating to British colonies or dependencies or to foreign countries. (2) To reply to inquiries which can be answered by a short note or by word of mouth, or by reference to published commercial data and statistics. (3) To direct inquirers who want special information to the proper quarter, *e. g.*, to the Commercial Department of the Foreign Office, the office of a particular colony, Chamber of Commerce, the Imperial Institute, and so forth. The proposed office would also bring together all the information contained in the diplomatic and consular reports bearing upon particular industries and the state of the market for particular classes of goods.

UNIVERSITY AND EDUCATIONAL NEWS.

DR. WILLIAM P. GRAHAM has been appointed associate professor of electrical engineering in Syracuse University.

AT the Leland Stanford, Jr., University Mr. F. Atheling has been appointed assistant in mathematics and Mr. F. B. Baum assistant in electrical engineering.

THE corporation of Brown University will hold its annual meeting on September 8th. A successor to President Andrews will probably not be selected, but a committee will be appointed to consider the question. The report now goes that the Rev. Edward Judson, pastor of a Baptist church in New York city, is likely to be selected. The President of Brown University must be a Baptist.

MR. J. A. JOHNSTON has been appointed professor of physics and mechanics at the Royal Agricultural College at Cirencester.

DRS. LENK AND FLEISCHMANN, associate professors of mineralogy and zoology, respectively, at Erlangen, have been promoted to full professorships. Dr. Heim has been appointed professor of botany in the Agricultural College at Vienna.

DISCUSSION AND CORRESPONDENCE.

BASIL VALENTINE.

TO THE EDITOR OF SCIENCE: The very interesting article by Mr. C. S. Pierce in your issue of August 12th reminds me that several years ago I bought, in Brentford, England, a Latin edition of the 'Triumph-Wagen des Antimonii,' published in 1646. As Mr. Pierce makes no mention of this edition, it may possibly be worth while to call attention to it. The title-page reads as follows:

"CURRUS TRIUMPHALIS ANTIMONII: FRATRIS BASILII VALENTINI Monachi Benedictini. OPUS *Antiquioris Medicinæ & Philosophiæ Hermeticæ studiosis dicatum.* E Germanico in Latinum Versum opera, studio & sumptibus Petri Joannis Fabri Doctoris Medici Monspeliensis. *Et notis perpetuis ad Marginem appositis ab eodem illustratum.* TOLOSÆ. Apud PETRUM Bosc, M.DC.XLVI."

Dr. Faber dedicates the book to the 'illustrissimo ac reverendissimo D.D. Carolo de Mont-chal, Archiepiscopo Tolosano Regis Christianissimi Consiliano Meritissimo.' He also contributes an introduction. "The book was the property of one Samuel Whitlock, who has made numerous marginal notes.

"The existence of this edition, while proving nothing, appears to show that about forty years after the original publication no doubt was entertained as to the authorship of the work."

T. D. A. COCKERELL.

MESILLA PARK, NEW MEXICO, August 16th.

SCIENTIFIC LITERATURE.

Fossil Plants for Students of Botany and Geology. By A. C. SEWARD, M.A., F.G.S. With Illustrations. Vol. I. Cambridge. 1898. Pp. xviii+452. Cambridge Natural Science Manuals. Biological Series.

There has been for many years an increasing demand for a work on fossil plants that shall be at once comprehensive, scientific, and sufficiently popular for the lay student. Balfour's 'Introduction to the Study of Palæontological Botany,' Edinburgh, 1872, was too elementary, and was restricted to British material. Saporta's 'Monde des plantes avant l'apparition de l'homme,' Paris, 1879, comes nearer to the ideal, but it is now old and out of date in view of the rapid advance of the science. 'L'évolution du règne végétal,' by Saporta and Marion, in three small volumes, 1881-1885, is much more special and somewhat popular and an exceedingly suggestive work. Count Solms-Laubach's 'Einleitung in die Paläophytologie,' Leipzig, 1887, is the work of a specialist, and proceeding professedly from the botanical standpoint does not claim to cover the whole field, and is really a series of special investigations, largely confined to internal structure, and arranged in no systematic order (*e. g.*, the 'Cycadeæ' are treated before the ferns, and the Calamariæ before the Lepidophytes). The English translation of this work, published four years after the German edition, contained no revision, although there had been great advance during this interval in solving the problems discussed.* Sir William Dawson's 'Geological History of Plants,' New York, International Scientific Series, 1888, is little more than the geological history of the Devonian of Canada, although a pleasant book. The second part of Zittel's

*See SCIENCE, Vol. XVIII., No. 464, New York, December 25, 1891, pp. 360-361.

'Handbuch der Palæontologie' is a large volume and constitutes a manual of fossil plants. It was begun by Schimper in 1879 and completed by Schenk in 1890. It treats the subject systematically and, therefore, is only adapted to the use of the advanced student or special investigator. Schenk's subsequent abridgment of this, entitled: 'Die fossilen Pflanzenreste,' Breslau, 1888, so far from popularizing it, condenses it to such a degree that it is of little use even to the latter class.

The above-named seven works, to which might, perhaps, be added the 'Sketch of Paleobotany' in the Fifth Annual Report of the U. S. Geological Survey, Washington, 1885, and the article on fossil plants in Johnson's Universal Cyclopædia (Vol. VI., pp. 639–645), constitute about the only attempts heretofore made to present a general view of the science of paleobotany without introducing descriptions of species. Potonié's 'Lehrbuch der Pflanzenpalæontologie mit besonderer Rücksicht auf die Bedürfnisse des Geologen,' begun in 1897, has now reached the third fascicle, but it bids fair to be even more technical than any of those already mentioned.

We have now before us the first volume of another comprehensive work on the general subject of fossil plants, written by one who is thoroughly equipped for his task, especially from the botanical side, and the first question that arises is as to whether it responds in any more satisfactory way than the rest to the real demand in this line, viz., the demand already mentioned for popular scientific treatment of the whole subject of extinct plant life in its relation to living plants and to geologic time. To this question the answer must be decidedly in the negative. The work fills no 'long-felt want,' and must be regarded simply as another added to the considerable number of technical treatises designed for the advanced student only. It is remarkable how, in the production of such works, the general educational requirements are ignored and only those of special research considered. The leading motive with each author seems to be to see how much better he can treat the more advanced and recondite aspects of the subject than his predecessors have done, and thus we have a multitude of very similar works, each making a slight advance upon the preceding one.

Dismissing, then, at the outset all idea of a new departure or a fresh and novel presentation of the science of fossil plants, such as should be calculated greatly to multiply the number of persons who interest themselves in them, let us apply ourselves to the task of examining the work as it is. A criticism of a book because it is not something else can be justified in a case like the present, where there is sore need of a form of treatment which the author is fully competent to furnish and proves that he has leisure to do by making a book for which there is no special call. Still, for English readers, and especially for the very small and constantly diminishing number of students who cannot readily handle the French and German languages, the present work will be grateful and far better than a translation. Moreover, I do not hesitate to say that, aside from its being fully up to date, it is decidedly the best of the works thus far produced. Of course, this ought to be the case, not only because it is the latest, whereby all previous contributions could be laid under tribute and their defects profited by, but also because it has as its author a man with an exceptional equipment for his task, especially as not being too great a specialist, *i. e.*, not having narrowed down to any one of the main lines, as is so often the case, which gives such an uneven and one-sided character to most works of the kind.

The work is divided into two parts, the first of which is called 'General' and occupies 115 pages, while the second, or 'Systematic,' part includes the remainder of the volume and may extend through the whole of the second volume. It is, therefore, essentially a systematic work.

The 'General' part consists of a 'Historical Sketch' of 11 pages; a chapter on the 'Relation of Paleobotany to Botany and Geology,' 10 pages; one on 'Geological History,' 32 pages; one on 'The Preservation of Plants as Fossils,' 39 pages; one on 'Difficulties and Sources of Error in the Determination of Fossil Plants,' 17 pages; and one on 'Nomenclature,' 6 pages. As a book for advanced students only, the historical sketch is merely formal and as-

sumes a knowledge of all the details, but gives some references. The second short chapter is merely introductory, and the third, which is a fairly good *résumé* of the stratigraphical conditions, with a columnar section after McKenny Hughes, and a treatment of each formation in ascending order, has the defect of failing to connect the several periods closely enough with the forms of vegetation specially characterizing them. As the treatment in Part II. is botanical and not geological, this could only be done here. A fine opportunity is therefore lost.

The fourth chapter, treating of the mode of deposition of plants, is excellent and opportune, and is the best summing-up of an obscure but important subject that we have. The author seems to have realized the need of such a survey and has made it correspondingly clear that most of the popular error relating to fossils is due to ignorance of their modes of preservation in the rocks, and nothing could be more educative than a full and lucid presentation of the facts so far as known. It would be too much to expect this in a work devoted to fossil plants, but any light on the subject is valuable. Here, however, a general knowledge of geology is presupposed, and this chapter, which might well interest many geologists, is not adapted to the needs of the untrained reader.

The fifth chapter, on the difficulties to be overcome, is very cautiously written and cannot fail to exert a wholesome influence on workers in this field. It proceeds mainly from the usual standpoint of both botanists and geologists, who never tire of emphasizing the unreliability of paleobotanical data. Some excellent examples are given of the possibilities of error, and the author's modest disinclination to defend his cause seems to leave the case with the opponents of the science. This is better than an ardent defence, but he might at least have answered some of the objections that are based on ignorance of the science, and most of the cases are of this class. The errors that have been made are either due to superficial observation and poor work, or else they are committed by geologists themselves. Of this latter class are most of the instances where 'problematical organisms' coming from early formations have been referred to the plant kingdom and called 'fucoids' or 'algæ.' It is the geologists and 'paleontologists' who have done most of this, and the paleobotanists, who came later, merely found them there. They, however, are always held responsible.

As an illustration of possible carelessness on the part of paleobotanists, we may take the case mentioned by our author on page 97 of the similarity of some Polygonums to Equisetum. He says: "Without a careful examination of the insignificant scaly leaves borne at the nodes this mistake might be made." The answer is that the careful investigator would not overlook these characters, however 'insignificant.' So, too, the case of *Kaulfussia*, a fern so unlike those with which we are familiar, simply shows the necessity that the paleobotanist acquaint himself with all kinds of ferns and not be limited to those of his particular neighborhood or country.

Botanists, acquainted only with plants as they now exist, have, as a general thing, not grasped the meaning of modification with descent, although they may often borrow that phrase from Darwin and apply it in a vague sense. They, therefore, have no patience with fossil plants that differ considerably from living ones, and think it foolish to try to name and classify them. When it was discovered that *Baiera*, which had first been classed as a fern, belonged to the line of *Ginkgo*, and had to be transferred to the Taxaceæ, it was thought that the paleobotanists had been guilty of an egregious mistake. But now that *Ginkgo* has been found to bear antherozoids, and therefore to be much nearer to a fern than to a yew, the mistake is found to have been that of the botanists, while the paleobotanists, in referring it to the ferns, had come much nearer to truth.

In Part II. the treatment is from the lowest forms upward, but this volume closes long before the Pteridophyta, or Vascular Cryptogams, have been disposed of. In fact, only two classes of them are treated, the Equisetales and the Sphenophyllales. Over 100 pages are devoted to the Thallophyta and only 13 to the Bryophyta. Nearly all the classes are briefly treated, whether any of them have been found fossil or not. In a large number, however, fossil forms have been reported, and the field of extinct

micro-organisms is now one of the most fascinating departments of paleobotany. To mention some of these in their systematic order, we have the Coccoliths of the Lias and Cretaceous made known by Sorby and Rothpletz, though their botanical position is doubtful; the calcareous algæ (Schizophyceæ) of various seas, including our Great Salt Lake; the oolitic grains containing calcareous tubes in rocks of various ages, some of which, as, *e. g.*, *Girvanella*, have been carefully studied and are very ancient (Ordovician); numerous forms, parasitic on fossil shells and corals, which bore into or through them and have puzzled the paleontologists.

Fossil bacteria are now well recognized and go back as far as the Devonian. Doubtless they were really coeval with the primal origin of life, if they did not themselves constitute it.

The old subject of fossil algæ, or fucoids (Bilobites, Eophyton, Spirophyton, Fucoides, etc, etc.) is disposed of very briefly. As these objects show no internal structure their true nature must remain problematical. Most of them are closely imitated by tracks made by various marine animals, and Mr. Seward seems to agree with Nathorst and others in accounting for them in this way. *Oldhamia* and *Dendrophycus* are believed to be of mechanical origin.

Upon fossil diatoms there is now an immense literature and Mr. Seward scarcely more than refers to it. He discredits, however, entirely the claim of Castracane to have found them in the Carboniferous. They are mostly Tertiary, Pleistocene or Plankton.

Among the green algæ (Chlorophyceæ) in the family Siphoneæ there occur some interesting fossil forms. We have here the rare case of a genus founded on extinct forms and subsequently discovered in the living flora. Such is the genus *Acicularia*. This case has the additional peculiarity that when first described by D'Archiac it was regarded as an animal. Quite a number of other genera of this group are found chiefly in the Eocene of the Paris basin, but also in older formations, *e. g.*, *Cymopolia*, *Dactylopora*, *Gyroporella*, *Sycidium* and *Vermiporella*, the last of which is Silurian. Throughout all this the general tendency has been to restore to the vegetable kingdom forms that had been regarded as animal.

Of red algæ (Florideæ, Rhodophyceæ) the principal fossil forms belong to the Nullipores, which form banks resembling coral reefs. The two best known genera are *Lithothamnion* and *Lithophyllum*. They are mostly Tertiary or Upper Cretaceous. The genus *Selenopora*, however, ranges from the Ordovician to the Jurassic.

To the brown algæ (Phæophyceæ) is referred the remarkable Prototaxites of Dawson, a land plant or tree of the Silurian and Devonian, first thought by Sir Wm. Dawson to be coniferous, as the name implies, but subsequently found to have nearly the structure of kelp, for which reason, contrary to the rules of nomenclature, Carruthers changed the name to *Nematophycus*, and still later Dawson and Penhallow proposed to call it *Nematophyton*, neither of which names can stand. Its history was popularly written by Sir William in his Geological History of Plants.

The fossil fungi are briefly treated with proper reservations and the opinion expressed that Meschinelli's list in the tenth volume of Saccardo's 'Sylloge Fungorum' 'includes certain species which are of no botanical value.'* The alleged Carboniferous fungus, *Incolaria securiformis*, described by H. Herzer from Ohio, in which the mycelia are said to be '1½ to 2 inches in diameter,' certainly did not deserve mention in such a work as this. The occurrence of fungi as diseases of fossil plants is an interesting fact and is properly dealt with.

Mr. Seward erects the Characeæ into a great group or subkingdom, the Charophyta, coordinate with the Thallophyta, Bryophyta, etc. The genus *Chara* is well known in the fossil state from the occurrence of great numbers of its peculiar so-called 'fruits,' consisting of the calcareous shells enveloping the oospores which always have characteristic spiral markings. Most of them come from the Tertiary, but they are found in the Wealden and the Jurassic, and one form strongly suggesting a *Chara* was found in Devonian rocks at the Falls of the Ohio and

*Since the appearance of Mr. Seward's volume Meschinelli has brought out a fine illustrated volume (Fungorum fossilium omnium hucusque cognitorum Iconographia, XXXI. tabulis exornata, Vicetiæ, 1898), which will furnish a basis for forming a more correct judgment of his work.

named by Dr. F. H. Knowlton *Calcisphæra Lemoni.*

Both of the great families of the Bryophyta, the Hepaticæ and the Musci, are found in the fossil state. Of the former the best known belong to *Marchantites* and closely resemble the common living liverwort *Marchantia*. They are found as low as the Oolite (*M. erectus* Leckenby), but also in the Wealden and the Tertiary. For the family of mosses Mr. Seward does not even mention the numerous well authenticated forms so common in the peat bogs of Europe and in the amber, but confines himself to the ancestral types that have been called *Muscites*, one of which (*M. polytrichaceus* Renault and Zeiller) dates back to the Carboniferous. The absence of this type throughout the entire Mesozoic is doubtless accidental and will perhaps be supplied by future research. The other forms thus far known are Tertiary.

As already remarked, the present volume does not complete the great group or subkingdom of Pteridophyta, dealing only with the two classes Equisetales and Sphenophyllales, and leaving the two most important classes, Lycopodiales and Filicales, for future treatment.

The Equisetales include the fossil genera *Equisetites*, *Phyllotheca*, *Schizoneura*, *Calamites* and *Archæocalamites*. These are all very fully discussed, and although the literature is large, especially that relating to the Calamariæ, still much of the information contained in this work is either new or supported by fresh illustrations. The author follows largely the line of Williamson's work, and his conclusions can be relied upon as the last word that the science has to offer. It would be too much to follow the various steps in his reasoning, and it must suffice to point out that, while retaining the genus *Archæocalamites* of Stur from the Devonian and Lower Carboniferous (Culm), he regards these pithcasts as probably forming a transition from true *Calamites* to *Sphenophyllum*, or, rather, to use his language, "we have evidence that the *Calamites* and *Spenophyllum* were probably descended from a common ancestral stock, and it may be that in *Archæocalamites* some of the *Spenophyllum* characters have been retained; but there is no close affinity between the two plants."

That Mr. Seward should have erected the single fossil genus *Sphenophyllum* into a class, Sphenophyllales, coordinate with the Lycopodiales, that include the Lepidophytes and the Filicales, or ferns, may surprise some botanists, but it must be remembered that, notwithstanding a certain superficial resemblance, *Spenophyllum* has persistently refused to identify itself with *Calamites* or *Asterophyllites*, and that from the standpoint of internal structure, so far as known, it has proved wholly unique among fossil plants.

In 1894 Messrs. Williamson and Scott, after the most prolonged investigation, declared that "the genus *Sphenophyllum* cannot be placed in any existing family of Vascular Cryptogams. Anatomically there are some striking points of resemblance to Lycopodiaceæ, but the habit and fructification are totally different from anything in that order. *Sphenophyllum*, in fact, constitutes a group by itself, which is entirely unrepresented in the present epoch, and the affinities of which cannot be determined until additional forms have been discussed."* Mr. Seward scarcely more than iterates this view when he says that "the genus *Sphenophyllum* is placed in a special class, as representing a type which cannot be legitimately included in any of the existing groups of Vascular Cryptogams. Although this Paleozoic genus possesses points of contact with various living plants, it is generally admitted by paleobotanists that it constitutes a somewhat isolated type among the Pteridophytes of the Coal Measures. Our knowledge of the anatomy of both vegetative shoots and strobili is now fairly complete, and the facts that we possess are in favor of excluding the genus from any of the three divisions of the Pteridophyta." He then proceeds with full descriptions and excellent illustrations to work out all the characters of the genus. There is scarcely a better example of what has been called a comprehensive or prophetic type in botany, and Mr. Seward has well expressed this view in the following words: "To put the matter shortly, *Sphenophyllum* agrees with some Lycopodinous plants in its anatomical features; with the Equisetales it is connected by the verticillate disposition of the leaves, and some of the

*Proc. Roy. Soc., London, Vol. LV., p. 124.

forms of *Sphenophyllum* strobili present features which also point to Equisetinous affinities." As to the probable derivation or genealogy of this form he quotes the Presidential address of Dr. D. H. Scott, made to the Botanical Section of the British Association in 1896, as follows: "One may hazard the guess that this interesting group may have been derived from some unknown form lying at the root of both Calamites and Lycopods. The existence of the Sphenophyllæ certainly suggests the probability of a common origin of these two series."*

In the above hasty sketch only a few salient points have been seized merely as samples of the character of the work, and the reader must go to its well laden pages if he is to obtain any adequate idea of the wealth of information that it contains. Teachers and advanced students, or even original investigators along these lines, will await with some impatience the appearance of the second volume.

LESTER F. WARD.

WASHINGTON, D. C.

SCIENTIFIC JOURNALS.

THE *Astrophysical Journal* for August opens with an article on observations on stellar motions in the line of sight contributed from the Emerson McMillin Observatory by Professor H. C. Lloyd. There is an article on the concave grating by Mr. S. A. Mitchell and a number of minor contributions. The greater part of the number is, however, taken up by an article on the series spectra of oxygen and sulphur and selenium by Drs. Runge and Paschen.

THE September number of the *Educational Review* contains articles by Hugo Münsterberg on 'Psychology and Education;' Gabriel Compayré on 'Contemporary Education in France;' William T. Harris on 'The Use of Higher Education;' Charles W. Eliot on 'The Older and the Newer Colleges;' Friedrich Paulsen on 'Examinations;' Walter L. Hervey on 'What German Universities offer to American Students of Education,' and Hiram M. Stanley on 'The Teaching of Psychology.'

THE current number of the *Atlantic Monthly* contains two articles of special interest to men of science. Dr. W J McGee takes the fiftieth anniversary of the American Association as the occasion for an article on the advance of science during that period, patriotically maintaining that America must be credited with one-half of its progress. Professor Simon Newcomb contributes the second installment of his 'Reminiscences of an Astronomer,' describing his astronomical work abroad and his visits to European observatories. Professor Newcomb demonstrates that scientific eminence is compatible with an admirable literary style.

THE announcement made in this JOURNAL some time since of the plan for the publication of a journal by the Illinois Hospital for the Insane has been carried into effect by the issue of the first number of a quarterly journal to which the queer name *The Psychiater* has been given. It contains four articles by members of the staff of the Hospital: 'Professional Work in Hospitals for the Insane,' by Dr. W. G. Stearns;' 'Three Cases of Brain Tumor,' by Dr. A. F. Lemcke; 'The Early Diagnosis of Paretic Dementia,' by Dr. V. Podstata, and 'Laboratory Psychology as applied to the Study of Insanity,' by Dr. W. O. Krohn. The number extends to 66 pages; the subscription price is $2.00 per annum.

THE *Journal of Tropical Medicine*, edited by Dr. James Cantlie and Dr. W. J. Simpson, and published by Messrs. John Bale, Sons & Danielsson, London, began publication on August 15th, and will be issued monthly hereafter. The first number is mainly occupied by the report of the proceedings of the Section of Tropical Diseases, at the annual meeting of the British Medical Association in Edinburgh.

NEW BOOKS.

Lehrbuch der anorganischen Chemie. DR. H. ERDMANN. Braunschweig, Friedrich Vieweg und Sohn. 1898. Pp. xxvi + 753. 18 Marks.

A Text-book of Geodetic Astronomy. JOHN F. HAYFORD. New York, John Wiley & Sons; London, Chapman & Hall. 1898. Pp. ix + 351.

Laboratory Directions for Beginners in Bacteriology. VERANUS A. MOORE. Ithaca. 1898. Pp. vi + 89.

* British Association Reports, Liverpool Meeting, 1896 (1897), p. 1006.